Established by BENJAMIN SILLIMAN in 1818.

THE

AMERICAN JOURNAL OF SCIENCE.

EDITOR: EDWARD S. DANA.

ASSOCIATE EDITORS

PROFESSORS GEO. L. GOODALE, JOHN TROWBRIDGE, H. P. BOWDITCH AND W. G. FARLOW, OF CAMBRIDGE,

PROFESSORS O. C. MARSH, A. E. VERRILL AND H. S. WILLIAMS, OF NEW HAVEN,

PROFESSOR GEORGE F. BARKER, OF PHILADELPHIA,
PROFESSOR H. A. ROWLAND, OF BALTIMORE,
MR. J. S. DILLER, OF WASHINGTON.

FOURTH SERIES.

VOL. VII—[WHOLE NUMBER, CLVII.]

No. 37.—JANUARY, 1899.

NEW HAVEN, CONNECTICUT.
1899.

TUTTLE, MOREHOUSE & TAYLOR, PRINTERS, 125 TEMPLE STREET.

Published monthly. Six dollars per year (postage prepaid). $6.40 to foreign subscribers of countries in the Postal Union. Remittances should be made either by money orders, registered letters, or bank checks.

RETAILING OF THE FAMOUS

TRAUTWINE COLLECTION.

We have just purchased entire, one of the first among great American collections, in point of species, sub-species and varieties represented in excellent type specimens. It shows few efforts at display, but is a gathering of over 6,000 specimens, including hundreds of rare numbered species not found in the average collection, and nearly a dozen which are to be seen on the desiderata lists of the most complete American and European collections.

John C. Trautwine, Civil Engineer and Mineralogist, was born in Philadelphia in 1810. He began the collecting of minerals about 1835 and continued until his death in 1883. The collection was built up through exchange, purchase and extensive foreign travel. It may justly be said to cover the period of 1840–70, illustrating with wonderful completeness the mineralogical discovery of the time—so well in fact, that the collection was studied by nearly all of his mineralogical contemporaries in America. Much of this discovery is found recorded to-day only in the *nomenclature* of the science; good examples are largely foreign to recent collections. Types and localities are shown in great variety under all important and many obscure species. Labels are models of scientific accuracy and neat penmanship, being small and attached to specimens. There are many duplicates, otherwise it would be useless to publish a list, as specimens will sell at sight. The short list of more important things will be mailed on application. Prices vary from about 50c. to $5.00 more or less. *We know of no minerals so universally desired as the old historical ones, and they are here by the thousand. Familiar minerals from the original localities from which they take their name, are frequent. South American and European localities fully represented.*

ABOVE IS AN OPPORTUNITY

which is not offered collectors once in ten years.

A TRIP TO THE

BROKEN HILL MINES, N. S. W.

Over 1,100 pounds of splendid crystallizations have just arrived as the result of a five weeks' trip of our special salaried collector. No more than brief mention can be made here of the leading kinds. Of some a considerable supply was obtained and old prices are greatly lowered. They are far superior to what has been on the market heretofore. Our illustrated supplement to appear late in January will describe them fully—mailed free. Send for it. The full page engraving of stellate twin Cerussite, coated with Anglesite xls, is an artistic success and illustrates a grand crystallization.

STOLZITE, gem like xls on gangue. Rare!!

RASPITE (with Stolzite) gem like xls on gangue. New!! Rare!!!

CERUSSITE. Masses of crystals in six-rayed stellate twins; also "V" shaped twins!!

ANGLESITE xls coating the foregoing. Some choice museum groups at low prices, for this rare combination!!!

EMBOLITE crystals and sponge-like masses, one-half former prices.

PYROMORPHITE, masses of bright, brown xls.

IOYDRITE, cryst. Rare!!

The Trautwine and Broken Hill minerals, together with other December accessions, will be placed on sale January 4th.

Dr. A. E. FOOTE,

WARREN M. FOOTE, Manager.

DEALER IN MINERALS,

1317 Arch Street, Philadelphia, Pa., U. S. A.

Established 1876.

THE

AMERICAN JOURNAL OF SCIENCE

[FOURTH SERIES.]

ART. I.—*The Thermodynamic Relations of Hydrated Glass;** by C. BARUS.

1. FURTHER treatment of the fusible water-glass described in the preceding communication† has brought out the following points: During the first or opaque stage of the reaction of hot water on glass (200°), volume-contraction ($\frac{v}{V}$) and increase of compressibility (β) are both marked phenomena. During the second stage the water-glass becomes more and more clear and limpid. Volume-contraction falls off asymptotically to zero. Compressibility, after passing through a pronounced maximum which may be even larger than $500/10^6$ per atmosphere, diminishes with great rapidity to the probable isothermal value for pure water (about $100/10^6$). The relation of change of compressibility to the corresponding volume-contraction (per unit of volume, cold), i. e. $\delta\beta/(\delta v/v_0)$, remains throughout of nearly the same order, lying within an interval of $10/10^6$ to $20/10^6$, and nearer the former limit so far as measurable. The total apparent volume-contraction of the hot column of water-glass may reach 30 per cent.

2. On cooling *bubbles* appear in the clear water-glass in great number, showing it to contract on solidifying from the center outward (centrifugally), like a Prince Rupert drop. The solid water-glass is in appearance as hard and brittle as ordinary glass,

*Read before the Nat. Academy of Sciences, Nov. 16th, 1898.

†This Journal (4), vi, p. 270, 1893; cf. this Journal (3), xli, p. 110, 1891. The experiments of this paper ending with compressibilities as high as $200/10^6$, relate chiefly to the opaque stage.

from which it differs in refraction and density. Capillary tubes at the end of the process have become glass rods. The original thread of water is replaced by a solid core of water-glass more than twice the original diameter.*

Nevertheless all capillary tubes with a solid core of this kind *break* throughout their length in the lapse of time, however carefully cooled. Cf. § 5.

3. An explanation of these phenomena may be given in the terms of the compressibility observed along the successive isotherms for the different concentrations of glass solution at 210°. This at first shows a relatively small value, implying a steep isotherm in a Clapeyron (pv) diagram. Thereafter compressibility passes through a relatively enormous value (over 5 times the initial result), implying a nearly horizontal isotherm. The reaction ends with even smaller compressibility than the first observed, implying steeper isotherms than the initial curves. Now although these isotherms are all at the same absolute temperature, the water-glass is becoming continually more concentrated and viscous. Hence the *corresponding temperatures* of the isotherms in van der Waals' sense are continually decreasing. It follows that the reaction considered as a thermodynamic process is a march through the *critical region* of certain phases of the water-glass examined.

4. In the light given by J. W. Gibbs's famous investigations, one may arrive at clear notions by adopting but two phases of the water-glass, for comparison. Many phases may coexist; two are selected in the interest of brevity and called phase 1 and 2, respectively. During the earlier stages of the reaction (dilute water-glass) phase 1 is stable. At the end of the reaction (concentrated water-glass, subsidence of volume contraction) phase 2 is stable. Both cases correspond to steep isotherms. Toward the middle region of the reaction (maxima of compressibility) phases 1 and 2 are mutually stable in presence of each other. Hence the horizontal isotherms corresponding to the critical region are cut through in a march from greater to smaller corresponding temperatures.

That phase 2 is really unstable during the first stage of reaction is shown by the approximate constancy of the values of compressibility, throughout intervals of pressure as high as could be applied. For instance, at 185°,

Interval, $p=$	20–100	100–200	200–300	300–400 atm.
$10^6\times\beta=$	146	144	142	146

And fifteen minutes later

$10^6\times\beta=$	188	176	201	189.

* Diameters of threads of water and of water-glass respectively in tube No. 4, ·024 and ·071^{cm}; in tube No. 5, ·033 and ·059^{cm}; in tube No. 6, ·053 and ·125^{cm}; etc.

Again, during the intermediate stage, water-glass is non-resilient: yielding remarkably to increase of pressure, it refuses to expand when pressure is removed. The last stage is again elastic but relatively incompressible.

The extreme compressibility of water-glass during the stated intermediate stage deserves especial comment. Beginning with igneous glass and water* with compressibilities of the order of $3/10^6$ and $100/10^6$ respectively at 210°, values are reached in water-glass which exceed $500/10^6$. One may even compare this result with so volatile a body as ether at different temperatures and between 100 and 200 atm., as follows:

Temperature =	29°	65°	100°	185°
$\beta \times 10^6$ =	156	207	305	741

Yet the water-glass solidifies in the cold to a hard colorless body quite resembling igneous glass.

5. Made in quantities in a large digester, water-glass is obtained as a nearly homogeneous compact body, adhering forcibly to the walls of the retort, from which it must be removed with wedge and hammer. A small lump held above a candle flame soon fuses with loss of water to a milk-white pumice. Left without interference in the cold for several weeks or months, it spontaneously cracks and crumbles, eventually becoming a loose mass breakable in the fingers, while the original lump could be broken only with a hammer. In the cold, therefore, phase 2 is unstable and passes back spontaneously into phase 1. Water is set free, probably under great pressure, and hence the gradual crumbling of the mass. When compared with the disintegration of minerals, we have here an example of an enormously rapid chemical reaction, in solids. The breakage of capillary tubes in the lapse of time instanced above, § 2, is thus explained.

*The rapidity with which water attacks glass vessels at 210° makes it impossible to obtain more than an estimate of its compressibility. See my earlier paper.

Brown University, Providence, R. I.

Art. II.—*Platinum and Iridium in Meteoric Iron;* by John M. Davison.

[Read before the Rochester Academy of Science on October 11, 1898.]

Some time ago a color reaction, given by potassium iodide with a residue from a solution of Coahuila meteoric iron, led me to suspect the presence of platinum. To test the matter, three attempts were made to separate this element from meteoric iron; the first with 108·6 grams of the Coahuila iron; the second with 500 grams of the same iron; the third with 464 grams of the Toluca iron. The hydrochloric acid solution of these irons left a fine black sediment consisting mainly of minute, tetragonal, prisms of rhabdite; minute, black, irregular crystals, which may also be rhabdite; carbon, and a little stony matter.

From this sediment platinum was obtained in each analysis. There was got from the 608·6 gms. of Coahuila iron 0·014 gms. of metallic platinum, and 0·0015 gms. of a black powder, insoluble in nitro-hydrochloric acid, but, after fusion with zinc, dissolving in that acid and giving with ammonium chloride a dark-red crystalline precipitate, which is probably ammonium iridi-chloride.

From the 464 gms. of Toluca iron a few crystals of potassium platinichloride were obtained. These show a reddish color, and probably contain iridium. The hydrochloric acid treatment of 500 gms. of Coahuila iron left 9·386 gms. of residue: that of the 464 gms. of Toluca iron left 0·944 gms. of residue, which contained more stony matter than did that from the Coahuila. This stony matter was much decomposed by the acid.

Careful search was made for microscopic diamonds. None were found in either meteorite. The few transparent grains, left with the carbon after all soluble matter had been removed, were decomposed by hydrofluoric acid.

From these analyses all platinum utensils were, of course, carefully excluded, the reagents tested, and all precautions taken against accidental contamination.

ART. III.—*Studies in the Cyperaceæ;* by THEO. HOLM. VIII. On the anatomy of some North American species of *Scleria*. With figures in the text, drawn by author.

HAVING discussed the composition of the inflorescence in a previous article,* let us pass to examine the anatomical structure of some of our native species: *S. pauciflora* Muhl., *S. triglomerata* Michx., *S. oligantha* Michx., *S. Baldwini* Steud., *S. ciliata* Michx., *S. filiformis* Swtz., *S. Elliottii* Chapm., *S. Torreyana* Walp., *S. reticularis* Michx., *S. hirtella* Swtz. and *S. verticillata* Muhl.

The root.

All our species are perennial and the roots are generally very strong and develop especially from the lower side of the rhizome; they possess much the same structure as has been described before as characteristic of roots of other genera of this large order, but differ from these, however, by the development of the innermost three or four layers of the bark-parenchyma into a sheath of very thick-walled cells, which surrounds the endodermis. This sheath, in connection with the very thick-walled endodermis, forms a very strong mechanical support to the central cylinder. Otherwise the root shows an epidermis of usual structure, a hypoderm and an outer bark with large lacunes from the tangential collapsing of the cells, in contrast to the inner layers (B in fig. 1), which, as described above, forms a very solid tissue.

The endodermis represents a typical O-endodermis, and surrounds a pericambium of normal structure. There are several large vessels in alternation with groups of leptome, and the innermost part of the central cylinder is occupied by a large mass of thick-walled conjunctive tissue.

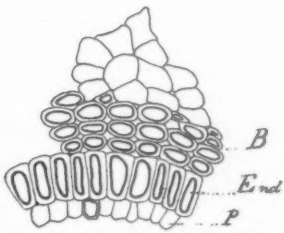


FIG. 1. Root of *S. pauciflora;* transverse section. B, inner bark; End., endodermis; P, pericambium. ×400.

This structure of the root was observed in species from various localities; from low, swampy ground and from dry, sandy soil in High Pine woods of subtropical Florida.

* This Journal, vol. v, January, 1898, p. 47.

The rhizome.

While the ramification of the stem underground is sympodial in our species, we may, nevertheless, distinguish three forms or modes of growth, viz: cespitose, creeping and tuberous. The first of these is exhibited by *S. verticillata*, and partly, also, by *S. reticularis* and *S. Torreyana*, and does not differ from the usual cespitose rhizomes of other Cyperaceæ. *S. ciliata* and *S. hirtella* have creeping rhizomes reminding one of *Fuirena scirpoidea*, which we have described in a previous paper.* The third form, the tuberous, is well exemplified by *S. pauciflora* and partly, also, by *S. filiformis* and *S. Elliottii*. In these species we notice that the rhizome is very much branched with relatively short internodes, densely covered by rudimentary sheathing leaves. The two basal internodes of each flower-bearing shoot are, furthermore, distinctly swollen so as to give the whole rhizome a peculiar knotted appearance. It is the basal internodes of the axis of first order that show such swelling, while the secondary axis grows out as a short, creeping and rather slender branch.

The development of these forms of rhizomes does not seem to depend upon the character of the soil, since the creeping is noticed in damp (*S. hirtella*) as well as in very dry sandy soil (*S. ciliata*). The cespitose form is especially characteristic of *S. verticillata*, which was collected in damp soil, like *S. reticularis* and *S. Torreyana*. The third form is common to species from dry, sandy to rich or swampy ground. Examining the internal structure of the rhizome of *S. pauciflora*, we notice a thick-walled hypoderm of about three layers inside the epidermis, and bordering on a large bark-parenchyma of thin-walled cells, which contain deposits of starch. The endodermis is not very well differentiated, but seems to consist of rather irregular, thick-walled cells. The innermost part of the rhizome consists of a large, starch-bearing fundamental tissue in which a number of collateral and perihadromatic mestome-bundles are imbedded, each of which is surrounded by layers of stereome. A corresponding structure is, also, noticeable in the tuberous base of the stems, but in these we observed a distinct and thin-walled endodermis, and noticed that the stereome around the mestome-bundles is only weakly developed.

In *S. ciliata* and *S. hirtella* we find a similar structure, but the cells of endodermis are more thin-walled. The stereome when compared with that of *S. pauciflora* is much heavier in *S. hirtella*, and much weaker in *S. ciliata*. Reservoirs of tannin were observed in all three species, and seemed to be especially abundant in the bark and fundamental tissue of *S. ciliata*.

*This Journal, vol. iv, July, 1897, p. 25.

The aerial stem

which bears the inflorescence is sharply triangular in our species, glabrous or sometimes covered with a few, unicellular hairs along the upper part of the edges, and these are sharply pointed and directed upwards. As in most of the other *Cyperaceæ* with sympodial shoots, the flower-bearing stem is in *Scleria* preceded by a few leaves, which winter over.

In its anatomical structure the stem of *S. pauciflora* shows a distinct cuticle and an epidermis with very thick outer walls. The characteristic siliceous cones which we have mentioned in our previous papers are, also, noticeable in this genus, in those cells of epidermis which lie over the stereome. The bark-parenchyma contains chlorophyll and consists of a compact tissue with several tannin-reservoirs scattered here and there. It is interrupted by the stereome, which covers the leptome-side of the mestome-bundles, reaching through the bark outwards to the epidermis. Viewed in transverse section, the stereome is seen to form a large group between the sides of each of the three angles of the stem, while the angle itself is occupied by bark-parenchyma. The mestome-bundles are arranged in two alternating bands, the outer consisting of large and small ones, the inner only of large ones completely imbedded in the pith, which is solid in this species. A like structure occurs in the lateral peduncles, which, however, are covered by hairs of the same shape which we have described as characteristic of the main stem.

The structure of the angle of the main stem seems to offer very good anatomical characters for the species of *Scleria*, and the following differences have been noticed. In *S. pauciflora* the angle is occupied by bark-parenchyma, which partly surrounds a very small mestome-bundle with little or no support of mechanical tissue on its leptome-side. Inside of the bark follow, then, heavy layers of stereome, which form a solid bridge between the two sides of the angle, and which support a very large mestome-bundle. This same structure is, also, characteristic of *S. triglomerata*, *S. oligantha*, *S. Baldwini* and *S. Elliottii*. In *S. reticularis*, *S. Torreyana* and *S. ciliata*, on the other hand, the angle itself is occupied by a small group of stereome which borders inwardly on some strata of bark parenchyma in which a very small mestome-bundle is situated. Next to that occurs a large mass of stereome which connects the two sides of the angle as in *S. pauciflora*, and which supports a mestome-bundle with a hadrome of considerable development. *S. verticillata*, *S. hirtella* and *S. filiformis* illustrate a third form of structure, since the angle contains here a single, large mestome-bundle, supported by a strongly developed stereome on the leptome-side.

Some other divergencies may be observed in the relative development of the bark-parenchyma and the stereome of the stem; we notice, for instance, a very thin bark-parenchyma in *S. oligantha*, in contrast to *S. filiformis* and *S. ciliata*, where the same tissue forms strata of rather large dimensions. The stereome seems to be present in larger groups and to be more thick-walled in *S. pauciflora*, *S. Baldwini* and *S. ciliata* than in any of the other species. The pith is broken by lacunes in *S. Torreyana*, *S. reticularis* and *S. filiformis*, but is solid in the other species.

The leaf.

The leaves of our species are provided with a tubular sheath and a long linear blade, which is very narrow in the North American species with the exception of *S. triglomerata*. *Scleria* is marked by the total absence of a ligula. Projections from the epidermis, such as spines or warts, are scarce, and *S. triglomerata* seems to be the only one of our species in which continuous rows of rather sharp and curved projections are visible above the stronger ribs in the leaf-blade. Hairs are, on the other hand, common, and occur as a more or less dense pubescence upon the sheaths of all our species, or as scattered, soft hairs along the margins of the leaf-blade, besides and not infrequently upon the upper face of the blade, covering the furrows between the stronger ribs.

The anatomical structure of the leaf-blade seems to be very uniform in our species, yet exhibits some peculiarities which enable us to separate the species, at least in groups by anatomical characters. In *Scleria pauciflora* the stomata are confined to the lower face of the leaf-blade, forming longitudinal rows underneath the mesophyll. The cells of epidermis are rather

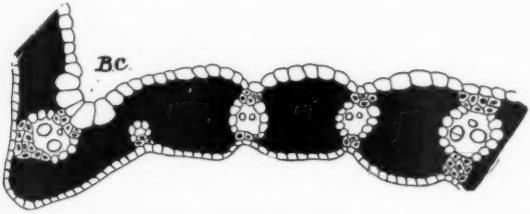


FIG. 2. Leaf of *S. pauciflora*; transverse section; B C, the bulliform cells. × 120.

large and thin-walled on both faces of the blade, and form a single group of the characteristic bulliform cells above the midrib (B C in fig. 2). The other cells of epidermis of the upper face are remarkably large, but without attaining the

shape or arrangement of proper bulliform cells. The mesophyll forms throughout a compact tissue, containing much chlorophyll and is differentiated as a palissade tissue on the upper face of the blade. Tannin-reservoirs are not uncommon in the mesophyll. Mestome-bundles of two degrees of development separate the mesophyll, which shows a distinct constriction at each bundle, as shown in the accompanying figure 2. A usual colorless parenchyma-sheath and a rather thin-walled mestome-sheath surround the bundles, the larger of which are supported by stereome on both faces, above and below. The smaller mestome-bundles show only a few stereome-cells on their leptome-side.

The same distribution of bulliform cells as representing only one group above the midrib is also met with in other species of *Scleria*, and appears to be the commonest arrangement. We have observed it in *S. triglomerata*, *S. oligantha*, *S. ciliata*, *S. filiformis*, *S. Elliottii*, *S. Baldwini* and *S. reticularis*. But in none of these species does the leaf-blade show the deep furrows which we observed in *S. pauciflora*, and which gives the section the peculiar constricted appearance. The epidermis-cells of the upper face are, however, also very large in these species, increasing in size towards one of the largest of the lateral ribs, but without becoming specialized as proper bulliform cells. It is, furthermore, characteristic of these species that one or two of the lateral ribs project very strongly on the upper face, while in *S. pauciflora* they were all situated below the surface, in shallow furrows. Stomata occur on both faces of the blade in these species, in contrast to *S. pauciflora*. Some, but slight, variations were also noticed in the thickness of the cell-walls of epidermis and stereome; we observed, for instance, a very thick-walled epidermis in *S. ciliata*, *S. Baldwini*, *S. filiformis*, and *S. Elliottii*; a thick-walled stereome in *S. ciliata* and *S. Baldwini*, besides that the mestome-sheath showed a more prominent thickening in these two species than in any of the others. *S. reticularis* is the only species in which the stereome on the upper face of the leaf-blade is separated by mesophyll from the mestome-bundles. Characteristic of the remaining three species: *S. Torreyana*, *S. hirtella* and *S. verticillata* is the presence of more than one group of bulliform cells, there being three between the larger lateral ribs in *S. Torreyana* besides the one above the midrib. In the two other species the epidermis between each two mestome-bundles and above the midrib is developed as bulliform cells, the number of groups corresponding to the width of the leaves, about four on each side of the keel of *S. verticillata*, eight or nine in *S. hirtella*. The other tissues, the mesophyll, with reservoirs of tannin, the stereome and the mestome-bundles show much the same

structure as described above for *S. pauciflora*, as regards their development and distribution.

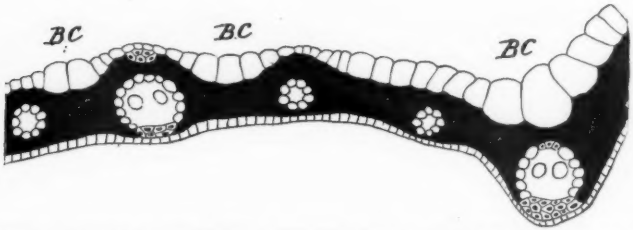


FIG. 3. Leaf of *S. verticillata;* transverse section; B C, bulliform cells. × 120.

Scleria verticillata and *S. hirtella* differ, however, from the other species of *Scleria*, which we have examined, and as a matter of fact from all the other Cyperaceæ which we have studied anatomically, by possessing some very peculiar incrustations of silica upon the radial walls of the bulliform cells. The accompanying figure 4 illustrates two bulliform cells in

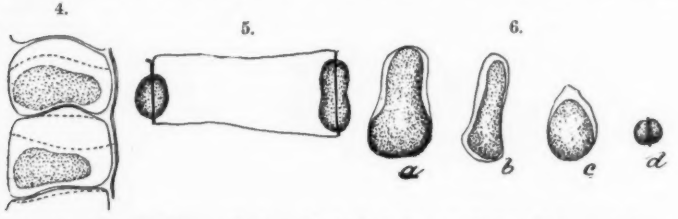


FIG. 4. Two bulliform cells from the leaf of *S. verticillata* with incrustations; transverse section. × 320.
FIG. 5. A macerated bulliform cell of *S. verticillata* with incrustations. × 320.
FIG. 6. Incrustations from bulliform cells of *S. verticillata*. × 320.

transverse section, with incrustations upon the radial-walls, the outline of which are indicated by dotted lines in our figure. These incrustations form granular masses of a whitish color and are present in almost all the bulliform cells, but varying somewhat in shape and size. By burning sections of the leaf to white ashes and then adding a few drops of hydrochloric acid these incrustations become very conspicuous and assume a clear brown color like sepia. Figure 5 illustrates a macerated bulliform cell, and we notice here that the incrustation has taken place to the same extent on both of the adjoining radial cell-walls. A part of the radial cell-wall upon which the incrustation takes place contains also silica and remains as fragments attached to the incrustations after they have been macerated, which is to be seen in the accompanying figure 6. Figs.

a, *b* and *c* show the incrustations as seen from within the cell with a part of the cell-wall still remaining; figure *d* represents one of the smallest incrustations, seen from above. These silicious incrustations dissolved in a concentrated aqueous solution of potassium in about forty-eight hours.

Silicious incrustations are also known to occur in the *Gramineæ*, and Dr. Aug. Grob has lately published a very important treatise of this subject.* He has, however, confined himself to the *Gramineæ*, and judging from his descriptions and figures, the incrustations which we have observed in *Scleria* differ very much from any of those that have been found in the *Gramineæ* or other monocotyledonous orders.

The pericarp of *Scleria* contains also a vast amount of silica. It lies in two distinct strata of which the outer one is built up by a homogeneous tissue of polyëdric cells; the inner part consists of a single layer of cells with very long and thin radial walls. It is the outer tissue that undergoes the incrustation, and when macerated the silicified cells form some very beautiful structures like stars, for instance, in *S. pauciflora* and others. Considered from an anatomical point of view, the North American species of *Scleria* show several characters in common; thus it does not seem probable to distinguish all the species by means of their structure alone. We have, nevertheless, enumerated the most salient points in the accompanying table, from which the anatomical characters may be readily seen, at least in some of our species.

	Leaf.					Stem.					
	Bulliform cells only above midrib.	Bulliform cells above midrib and three lateral groups.	Bulliform cells above midrib and four groups on each side.	Bulliform cells above midrib and eight or nine groups on each side.	Bulliform cells with incrustations.	Stereome separated from mestome-bundles by mesophyll.	Angle occupied by bark-parenchyma.	Angle occupied by stereome and two mestome-bundles.	Angle occupied by stereome and one mestome-bundle.	Pith solid.	Pith with lacunes.
S. pauciflora	+	—	—	—	—	—	+	—	—	+	—
S. triglomerata	+	—	—	—	—	—	+	—	—	+	—
S. oligantha	+	—	—	—	—	—	+	—	—	+	—
S. Baldwini	+	—	—	—	—	—	+	—	—	+	—
S. ciliata	+	—	—	—	—	—	—	+	—	+	—
S. filiformis	+	—	—	—	—	—	—	—	+	—	+
S. Elliottii	+	—	—	—	—	—	—	—	—	+	—
S. Torreyana	—	+	—	—	—	+	—	+	—	—	+
S. reticularis	+	—	—	—	—	—	—	+	—	—	+
S. hirtella	—	—	+	—	+	—	—	—	+	+	—
S. verticillata	—	—	—	+	+	—	—	—	+	+	—

*Grob, August, Beiträge zur Anatomie der Gramineen-blätter, Bibliotheca Botanica, Stuttgart, 1896, p. 34.

Although the first four of these species are not to be separated by the anatomical characters, which we have pointed out, they are nevertheless readily distinguished by their morphological; the other species seem on the other hand to be equally well distinguishable by anatomical and morphological divergences.

In considering the character of soil and climatological conditions of the localities from where our material has been brought together, one might feel inclined to designate these plants as belonging to xero- or hydro-philous societies. Their structural peculiarities, however, do not point towards any distinction of that kind. *Scleria pauciflora*, for instance, from wet ground in the vicinity of Washington, D. C., does not differ in any very marked degree from *S. triglomerata*, which we collected in dry sandy soil in subtropical Florida; furthermore *S. ciliata*, an inhabitant of the High Pine-woods of Florida, shows no strictly xerophytic characters when compared with *S. reticularis*, a bog plant. While certain species, as *S. reticularis*, *S. filiformis* and *S. Torreyana*, collected in a rather wet ground, possess a stem with a more or less broken pith, other species from similarly damp localities have perfectly solid stems. It seems as if the North American species of *Scleria* are very little susceptible to variation due to changes in environment and that they are not to be placed into any special society, either among the "xero- or hydro-phytes."

Brookland, D. C., August, 1898.

ART. IV.—*Concerning Regnault's Calorie and Our Knowledge of the Specific Volumes of Steam;* by G. P. STARKWEATHER.

THE volumes of saturated steam at various pressures customarily used are those determined from the latent heats. Since the latter depend almost entirely upon Regnault's experiments, the question of his 'calorie' is of importance. In calculating the 'heat of the liquid' and 'total heat' Regnault assumed that within the calorimeter range, say from 0° to 30° C., the specific heat of water was sensibly constant. Whether this is so or not depends upon the thermometric scale used. If mercurial it might be so, but if the scale was that of the air-thermometer, which is the one to which Regnault usually reduced his observations, it certainly would not.

Bosscha* in 1874 remarked that in the experiments under consideration there was no record of the calorimeter temperatures being reduced to the air-thermometer, and accordingly made corrections to Regnault's formula for 'heat of the liquid,' although he still assumed that the specific heat of water was constant within the calorimeter range. To this Regnault replied that the calorimeter temperatures were reduced to the air-thermometer, but as this was over twenty years after the experiments were conducted there has always been more or less uncertainty to many minds.

The writer hopes to present some evidence from Regnault's experiments themselves corroborating his statement, and will construct formulæ taking into account the variation of the specific heat of water from 0° to 30°. The agreement between Rowland and Griffiths† regarding this variation is so exact, and their methods were so accurate, that between the limits mentioned it can be regarded as determined. Their results are expressed according to the Paris nitrogen scale, but the specific heats according to Regnault's air-thermometer would not differ qualitatively from them, and ought not to differ much quantitatively. The only person, so far as the writer is aware, who has looked at the subject in the light of recent experiments is Ekholm,‡ but he concludes (it seems to the writer incorrectly) that Regnault's calorimeter temperatures were not reduced to the air-thermometer, and accordingly makes no corrections for the variation in the specific heat at low temperatures, supposing it to be constant according to the mercurial thermometer.

* Ann. Phys. und Chem., Jubelband, p. 549.
† Phil. Mag., xl, p. 449, 1895, and Proc. Roy. Soc., lxi, p. 479, 1897.
‡ Bihang till Handlingar Svensk. Vet. Akad., xv, 1889, No. 6, p. 27.

Before making use of Regnault's experiments on heat of the liquid it is well to note the error discovered by Velten* in them. In Regnault's table the second column gives the weight of cold water in the calorimeter, P; the third, the weight of hot water, p; the seventh, the temperature, T, of the hot water according to the air-thermometer; the eighth, the initial temperature of the calorimeter, t_0; the ninth, the final temperature of the calorimeter, t_1; the eleventh (t_1-t_0) corrected; the last, the mean specific heat between t_1 and T, x. Then we should have, according to Regnault's assumption that at low temperatures the specific heat is practically constant,

$$x = \frac{P(t_1-t_0)}{P(T-t_1)}.$$

Now Velten has found that out of Regnault's forty experiments in only five does his value of x agree with this formula; in twenty-two cases the difference is insignificant, while in thirteen cases there is complete disagreement. Velten has ascribed this discrepancy to errors in calculation, but it is very strange that erroneously calculated these values of x should bear a good agreement with the others and as 'correctly' calculated by Velten should not. Sutherland† has almost conclusively shown that the error is one in the copying of Regnault's numbers into the tables, namely, that Regnault in these thirteen experiments, which belong to a different series from the others, copied a wrong set of numbers for the weight of hot water, and that his values of x are the correct ones. Sutherland's proof is based on considerations of the cubic capacity of the calorimeter, as these very experiments show an unusually large amount of hot water. In fact, as the numbers stand, there is indicated a total weight of hot and cold water greater than the capacity of the calorimeter.

The writer has made corrections to Regnault's experiments on the heat of the liquid necessitated by the variation of the specific heat within the calorimeter range, but has found that Ekholm's formula fits as well as any. Although this was formed without the above mentioned corrections, nevertheless the latter are considerably smaller than the variations in the experiments themselves. Also in developing the formula Ekholm left out certain experiments which are those the corrections affect the most. The formula is

$$h = t + 0{\cdot}00000929\,t^2 + 0{\cdot}000000265\,t^3,$$

and is to hold only above 100°.

The unit here is the specific heat at 15° according to Reg-

* Wied. Ann., xxi, p. 45, 1884.
† Phil. Mag., xxvi, p. 302, 1888.

nault's thermometric scale, which will be denoted as Regnault's calorie. The formula may be incorrect towards 200° by about 0·3 per cent, but is quite accurate at 100°, since in this vicinity the corrections are very slight whatever be the thermometric scale. It gives for the mean specific heat between 0° and 100° the value 1·00358.

Now if Regnault's scale was that of the air-thermometer, this number should agree with the determinations made by other observers who have used that scale or ones not differing essentially from it. Such determinations have been made by Von Muenchausen,* Rowland,† Henrichsen,‡ Baumgartner,§ Velten‖ (two series, one by the method of mixtures, the other with the Bunsen ice-calorimeter), Dieterici,¶ Ludin,** Joly,†† and Reynolds.‡‡

Von Muenchausen's work, which was conducted by the method of mixtures, has been criticised by Rowland on the ground that the experiments were performed in an open vessel. An inspection of his tables reveals great discrepancies. Thus as a mean of row I he finds that the mean specific heat from 26°·70 to 42°·37 is 1·0033 times that from 20°·07 to 26°·70. This is impossible, for the specific heat reaches a minimum at 32°, by Rowland's experiments, and there would be necessitated a mean specific heat from 32° to 42° of 1·0033, the specific heat at 15°, c_{15}, being the unit. This mean specific heat would indicate for c_{42} the value 1·0102, an increase of 1·4 per cent in ten degrees. Moreover in rows II and III he finds that the mean specific heat from say 25°·7 to 42°·7 is 1·0037 times that from 17°·3 to 25°·7, an increase over the preceding, whereas according to Rowland's data it should be less. His formula makes c_{0-100} equal to 1·015 c_{15}.

The writer has made careful comparisons of a similar nature of the experiments of Baumgartner and Velten, and finds even worse discrepancies. Baumgartner makes the mean specific heat from 0° to 100° equal to 1·016 c_{15}, while Velten's two series make it respectively 0·9896 and 0·9929.

The experiments of Henrichsen were performed with the ice-calorimeter. Dieterici, who is an authority on the use of this instrument, has made a careful comparison of them with those of Velten carried out by the same method. He says (reference, p. 443): "The great differences which the experiments made with the ice-calorimeter show, make it probable that this instrument is unsuited for this investigation." More-

* Wied. Ann., i, p. 592, 1877.
† Proc. Amer. Academy, 1879–80, p. 120.
‡ Wied. Ann., viii, p. 83, 1879.
§ Ibid., viii, p. 648, 1879.
‖ Ibid., xxi, p. 31, 1884.
¶ Ibid., xxxiii, p. 417, 1888.
** Beiblaetter zu Wied. Ann., xx, p. 764, 1896.
†† Phil. Trans., clxxxvi A, pp. 322, 323, 1895.
‡‡ Nature, June 3, 1897.

over Henrichsen makes the ratio of the mean specific heat from 0° to 100° to that from 0° to 25° equal to 1·025, a number which is markedly larger than has been obtained by any other investigator.

So far we see that little or no dependence can be placed on the experiments. Rowland's work should be more reliable. His experiments make c_{20-100} equal to 1·0024 c_{18-28}, or reduced to c_{15} as a unit, c_{20-100} is 1·0049 c_{15}, which makes c_{0-100} equal to 1·0034 c_{15}. He mentions two other determinations and gives as the mean of all three that c_{0-100} is equal to 1·0041 c_{15}.

The very recent work of Ludin was performed with great care. He gives for c_{0-100} the value 1·00543 c_{15}.

Joly's determination of c_{0-100} was obtained by the use of his steam-calorimeter, and gives for its value 0·9957 c_{15}. Concerning the accuracy of this instrument we know nothing, and no details are given. He himself says he obtained much larger values in earlier experiments, but he considers this to be more accurate.

We have now left the determinations of Dieterici and Reynolds. These were both by obtaining the mechanical equivalent. Dieterici found by electrical methods (and using the ice-calorimeter) that c_{0-100} was equal to 42·436 megalergs. Griffiths* has pointed out that he made the error of using the "legal" instead of the "true" ohm, which reduces his value to 42·33. There is also a constant error† in experiments made by electrical methods of about one-quarter of one per cent due to the determination of the electrical standard of electromotive force, which reduces this to 42·225. This makes the mean specific heat between 0° and 100° equal to 1·00799 c_{15}. The experiments of Dieterici were performed with great care, were sixteen in number, and deviated from the mean at most 0·37 per cent, the probable error being 0·05 per cent. But they have one fault, that there is lacking a conclusive determination of the quantity of quicksilver displaced in the ice-calorimeter by a quantity of heat equal to the mean specific heat from 0° to 100°. Bunsen has found it to be 15·41 milligrams, Schueller and Wartha 15·442, and Velten 15·47; Dieterici takes the second value. Velten's values being uncertain, as has been shown, it seems as if less weight should be given to his determination, which would still further reduce Dieterici's value for the mean specific heat from 0° to 100°.

In total opposition to Dieterici stand the recent results of Reynolds. According to him the mechanical equivalent of the mean specific heat from 0° to 100° is 41·83 megalergs, which is

* Phil. Mag., xl, p. 446, 1895.

† Phil. Mag., xl, p. 449, 1895; Proc. Roy. Soc., lxi, p. 479, 1897, and Johns Hopkins Univ. Circular, No. 135, June, 1898, p. 54.

equal to the specific heat at about 20°. His experiments are as concordant as those of Dieterici.

Let us now compare Regnault with these other investigators. The table below gives the fractional deviations of c_{0-100} according to them from 1·00358 c_{15}.

(1) Experiments which are unreliable.

Von Muenchausen	(mixtures)	+0·0113
Velten	(mixtures)	−0·0139
Henrichsen	(ice-calorimeter)	+0·0214
Velten	(ice-calorimeter)	−0·0106
Baumgartner	(mixtures)	+0·0124
Joly	(steam-calorimeter)	−0·0079

(2) Experiments in which evidences of unreliability are not present.

Rowland	(mixtures)	+0·0005
Ludin	(mixtures)	+0·0018
Dieterici	(mech. equiv.)	+0·0044
Reynolds	(mech. equiv.)	−0·0050

The first set are grouped so far as possible into pairs of equal probability and nearly balance. Of the second set the last two balance, and the deviations in the first two are very small. As the numbers stand the positive deviations seem to rather outweigh the negative; some additional evidence on the negative side is afforded by the following: Sahulka* has found for the mechanical equivalent at 58° the value 426·262 kilogrammeters, or 41·81 megalergs, thus making c_{58} equal to 0·9981 c_{15}. Assuming the specific heat to vary linearly with the temperature from 35° to 100°, this would make the mean specific heat from 0° to 100° equal to 0·9992 c_{15}, the fractional deviation from the value we have assumed being thus −0·00436. This evidence is not entitled to very much weight, however, because Sahulka's experiments deviate from their mean over one-half of one per cent.

It is thus seen that the assumption that Regnault's thermometric scale was that of the air-thermometer makes his value of c_{0-100} agree well with that obtained by others. It cannot be more than 0·5 per cent out, and is probably much more accurate than that. Any error in it should be ascribed to the unit in which it is expressed rather than to inaccuracies in the experiments themselves.

For temperatures below 100° the writer has formed for his present purposes the following formula:

$$h = 1{\cdot}00449\,t - 0{\cdot}0001904\,t^2 + 0{\cdot}000001813\,t^3.$$

* Wied. Ann., xli, p. 748, 1890.

Two of the constants were determined so as to make c_{15} equal to unity and c_{0-100} equal to 1·00358, while the remaining constant was adjusted to give a good value to c_{30}; the mimimum value is reached at 35°. A better agreement might be obtained by the method of least squares, but since c_{0-100} is not too well known and the remaining data all lie below 40° such nicety would not be justified. Moreover the only use made of the formula is to obtain latent heats from total heats, and also the entropy of dry saturated steam, and the term given by this formula is very small in comparison with the quantities with which it is combined.

The formulæ adopted for the heat of the liquid give us the following for the entropy of water:

$$\eta_w = a \log_{10} T - bT + cT^2 - d.$$

	Below 100°.	Above 100°.
log a	3·173436	3·015698
log b	0·156626	$\bar{1}$·250174
log c	$\bar{3}$·065024	$\bar{4}$·229792
d	3328·0	2490·9

This gives the entropy in kilogrammeters (at Paris) per degree, the zero of entropy being that of water at 0° C. T is the temperature absolute, absolute zero being taken as —273°·7 C.

Regnault's ninth memoir, Memoirs of the Institute of France, vol. xxi, furnishes us with the greater part of our knowledge concerning the total and latent heat of steam. Other experiments have been made by Andrews,* Favre and Silbermann,† Berthelot,‡ Schall,§ Dieterici,‖ Hartog and Harker,¶ Griffiths,** G. Fuchs,†† A. Svensson,‡‡ W. Ramsay and D. Marshall,§§ and Harker.‖‖ All excepting those by Dieterici, Griffiths and Svensson are at, or in the close vicinity of, 100°. Those by Hartog and Harker and by Harker alone are admitted by the authors themselves to be inaccurate. In all the remainder there is doubt as to what unit the results are expressed in, and they are few in number. Taken at their face value they all give a remarkable confirmation of Regnault's determination at 100°. The following table, taken partly from Griffiths' paper on latent heats, shows this:

* Chem. Soc. Journal, 1849.
† Ann. de Chimie et de Phys., xxxvii, 1853.
‡ Comptes Rendus, lxxxv, 1877.
§ Berichte d. Chem. Gesell., xvii, 1884.
‖ Wied. Ann., xxxvii, p. 494, 1889.
¶ Proc. Manchester Phil. Soc., 1893–4.
** Phil. Trans., clxxxvi A, p. 261, 1895.
†† Inaug. Dissertation, Erlangen, 1894, and Beiblaetter zu Wied. Ann., xix, p. 559, 1895.
‡‡ Beiblaetter zu Wied. Ann., xx, p. 559, 1895.
§§ Rep. British Ass., 1895, p. 628.
‖‖ Mem. and Proc. Manchester Lit. and Phil. Soc. (4), x, p. 38, 1896.

Observer.	Temperature.	Number of Experiments.	Extreme values of L.	Mean L.
Andrews	100	8	530·8 –543·4	535·9
Favre and Silbermann,	99·81	3	532·59–541·77	535·77
Berthelot	100	3	535·2 –537·2	536·2
Schall	100			532·0
Fuchs	100			536·8
Ramsay and Marshall,	100			537·0
Regnault	99·88	44	533 0 –538·0	536·3

The greatest deviation of these mean values from Regnault's is about eight-tenths of one per cent. To get Regnault's latent heat from his total heat I have used the 'heat of the liquid' from the formulæ already developed.

Consider now Regnault's experiments on total heats. These are divided into four classes, those at or near 100°, those from 119° to 195°, those from 63° to 88°, and last the set from −2° to +16°. He has given as a formula to unite these

$$H = 606{\cdot}5 + 0{\cdot}305\,t.$$

Take the series at 100°, forty-four in number. Neglecting the first six, which Regnault does not regard as so accurate as the others, the mean is 636·67, and the greatest deviation from this is less than three-tenths of one per cent. If we admit the first six the greatest deviation is less than six-tenths of one per cent. When we consider the fact that Regnault purposely varied all his experiments in many ways so far as possible, in order to eliminate constant errors, this close agreement in so many experiments shows that the mean value given above is very exact.

The unit in which this is expressed is determined by the calorimeter range, the average of which was from about 8°·3 to 20°·9, from which range the individual experiments did not differ essentially. Accordingly the unit is the specific heat at 14°·6 according to Regnault's thermometric scale, or practically Regnault's calorie. This we have judged to be the specific heat at 15° according to Rowland's scale, and have investigated the possible error in that judgment. There will be accordingly the same possible error in the total heats.

Consider next the experiments above 100°, seventy-three in number. A comparison of the numbers given in Regnault's tables with those given by his formula follows: From 119° to 150° the deviations of the experiments from the formula vary from −0·36 per cent to +0·25 per cent, mostly negative, but are generally very slight. At 153°, or experiment number 32, there is a sudden jump to −0·5 per cent, and a deviation exists varying from −0·2 per cent to −0·65 per cent, averaging −0·5 per cent, and gradually increasing up to 175°·5. Here there is another sudden change, and the deviations vary up to

195° between +0·2 per cent and −0·2 per cent, mostly positive. These sudden changes are rendered much more prominent by the following table. In the first column is given the number of the experiment, in the second the temperature, and in the third the fractional deviation of the observed total heat from that calculated by Regnault's formula.

1	119·25	−·0009	−·0014	−·0011	38	155·7	−·0040	−·0025	−·0019
2	119·60	−·0018	−·0018	−·0015	39	156·5	−·0020	−·0005	+·0003
3	122·17	−·0025	−·0028	−·0025	40	157·1	−·0046	−·0031	−·0024
4	125·2	−·0013	−·0003	·0000	41	157·8	−·0040	−·0025	−·0018
5	125·5	−·0018	−·0008	−·0005	42	160·3	−·0039	−·0024	−·0016
6	127·2	−·0008	+·0002	+·0005	43	160·4	−·0034	−·0019	−·0011
7	129·0	−·0011	−·0001	+·0002	44	161·8	−·0030	−·0015	−·0007
8	134·4	+·0024	+·0015	+·0018	45	164·6	−·0050	−·0035	−·0026
9	134·2	+·0002	−·0007	−·0004	46	164·9	−·0024	−·0009	·0000
10	135·1	+·0013	+·0004	+·0007	47	171·6	−·0050	−·0035	−·0024
11	135·0	+·0023	+·0014	+·0017	48	172·6	−·0059	−·0044	−·0033
12	135·2	−·0002	−·0011	−·0007	49	172·6	−·0059	−·0044	−·0033
13	135·5	−·0013	−·0006	−·0002	50	172·8	−·0066	−·0051	−·0040
14	135·7	−·0009	−·0002	+·0002	51	173·1	−·0058	−·0043	−·0031
15	136·4	−·0008	−·0001	+·0003	52	173·4	−·0059	−·0044	−·0032
16	137·5	−·0016	−·0009	−·0005	53	173·9	−·0056	−·0041	−·0029
17	137·7	−·0020	−·0013	−·0009	54	174·0	−·0055	−·0040	−·0028
18	138·6	−·0006	+·0001	+·0005	55	175·3	−·0060	−·0045	−·0034
19	142·0	−·0009	−·0002	+·0002	56	175·5	−·0060	−·0045	−·0034
20	142·2	−·0016	−·0009	−·0005	57	179·3	+·0016	+·0031	+·0044
21	142·5	−·0036	−·0029	−·0025	58	179·6	+·0013	+·0028	+·0041
22	143·4	+·0002	+·0009	+·0013	59	179·6	+·0021	+·0036	+·0049
23	144·3	−·0018	−·0025	−·0021	60	180·0	+·0013	+·0028	+·0041
24	144·3	−·0013	−·0006	−·0002	61	183·2	·0000	+·0015	+·0029
25	145·3	+·0003	−·0004	+·0001	62	183·5	+·0005	+·0020	+·0034
26	145·4	−·0014	−·0021	−·0016	63	183·7	+·0005	+·0020	+·0034
27	145·6	−·0028	−·0035	−·0030	64	183·7	−·0011	+·0004	+·0018
28	146·5	−·0002	−·0009	−·0004	65	186·0	+·0020	+·0035	+·0050
29	147·6	−·0030	−·0037	−·0032	66	186·0	+·0026	+·0041	+·0059
30	149·0	+·0014	+·0007	+·0012	67	187·9	+·0009	+·0024	+·0040
31	150·2	+·0005	−·0002	+·0003	68	188·2	+·0026	+·0041	+·0058
32	153·5	−·0050	−·0035	−·0029	69	188·2	+·0005	+·0020	+·0037
33	154·1	−·0050	−·0035	−·0028	70	193·8	+·0006	+·0021	+·0040
34	155·1	−·0060	−·0025	−·0019	71	194·2	−·0022	−·0007	+·0012
35	155·2	−·0060	−·0045	−·0039	72	194·7	−·0008	+·0007	+·0027
36	155·2	−·0028	−·0013	−·0007	73	194·8	+·0001	+·0016	+·0036
37	155·3	−·0044	−·0029	−·0023					

It is at once evident what a remarkable jump takes place at number 32. Previous to this the deviations have been both positive and negative, mostly negative, and have averaged under 0·2 per cent. Now the deviations are all negative and rarely under 0·4 per cent. But the reason for this is evident from a glance at Regnault's tables. From number 25 to 32 the calorimeter temperatures are very nearly constant, averaging 11°·5 and 23°·5, or the results are in c_{17} as a unit. Now if, as we have seen to be almost certain, Regnault's thermometric scale is that of the air-thermometer, and if we express everything in terms of the specific heat at 15° as a unit, these total heats should be a little large, since the specific heat at 17° is

less than that at 15°. And it is to be noticed that three of the seven deviations in the experiments cited are positive. From precisely 32 on, however, the calorimeter measurements have all very nearly 4°·5 for the lower temperature and 18° for the upper, and the quantities of heat are therefore expressed in terms of c_{11}. Accordingly the total heats from 32 on are about 0·2 per cent too small and should be increased by that amount. This greatly smooths out the break at that place.

This point is also verified by experiments 8 to 23. In 8 to 13 the calorimeter range was 12°·5 to 24°, hence the unit is c_{18}, and the total heats should be a little large; such is seen to be the fact. In 13 to 23 the calorimeter range was 6° to 18°, the unit accordingly c_{12}, and the quantities of heat are too small. We find in fact that all the deviations except one are negative.

The first seven experiments do not bear this out quite so well. Experiments 1 to 4 are in about c_{16} as a unit, experiments 4 to 8 in about c_{13}, and hence the latter should show a slightly greater negative deviation of perhaps 0·1 per cent. This is not so, but the experiments are few in number and the deviations slight.

It should be pointed out here that it is not assumed that Regnault's formula is absolutely correct, but it is simply used as giving a smooth set of values from which to estimate the concordance of the experiments.

The writer considers that the facts here brought forward still further substantiate the essential correctness of the comparison of Regnault's calorimeter temperatures with the air-thermometer. Accordingly he has corrected Regnault's total heats so that they should all be expressed in the same unit, c_{15}, and has given in the fourth column of the table on page 20 the deviations of the total heats so corrected from those yielded by Regnault's formula. It will be seen that the formula actually fits the experiments much better than it appeared, the greatest actual deviation being about 0·5 per cent. This means in the latent heats a maximum deviation of about 0·7 per cent.

Experiments 1 to 57 indicate that the formula gives values slightly too great. At 57 there is another peculiar jump of about 0·75 per cent. The explanation of this is not so evident as in the case of number 32. It lies in the fact that as the temperatures became higher the experiments became more difficult to conduct. Regnault himself says (Memoir, p. 700) that after number 60 the apparatus required frequent repairs on account of the high temperatures. It therefore appears that the highest set of experiments, from 57 on, are of less weight than the others. If we take the ten experiments commencing with 47 which lie between 170° and 176° we find for their average fractional deviation −·0043, the maximum being

−·0051 and the minimum −·0035, the sum of the squares of the differences from the average being almost nil. If, on the other hand, we take the remaining seventeen experiments, lying between 179° and 195°, the average fractional deviation is +·0022, the maximum +·0041, the minimum −·0007. Here the extreme differences from the average are twice as great as in the preceding, while the sum of the squares of the differences from the average is considerable, thus showing their greater unreliability, apart from Regnault's own statement to that effect.

The writer has therefore considered it proper to change these average deviations by making the total heat for 190° a little smaller than that given by Regnault's formula. The equation formed is

$$H = 603{\cdot}2 + 0{\cdot}356\,t - 0{\cdot}00021\,t^2$$

to hold only above 100°. In the fifth column of the table (page 20) there are given the fractional deviations of the corrected total heats from this formula. It will be seen that up to 26 the experiments are satisfied as closely as possible. From 26 to 57 the deviations gradually increase on the negative side, while from 57 to 73 they are still more marked on the positive side. But 26 to 57 are greater in number than the latter, are more consistent in themselves, and, as we have seen, are more reliable. This justifies the greater weight given to them. The average deviation in the last seventeen experiments is +·0038. Even if the corrections due to the variation of the specific heat of water are not allowed, the formula still represents the experiments better than Regnault's.

The formula is correct at 100°, and I think we can say that at 200° it cannot be more than 0·4 per cent out, corresponding to an error in the latent heat of 0·6 per cent.

Consider now Regnault's experiments below 100°. In the first six of the twenty-three from 88° to 63° the calorimeter temperatures averaged about 7° and 19°, hence the quantities of heat are expressed in c_{13} as a unit. Experiments 7 to 13 have for a calorimeter range 9° to 21°, or are in c_{15} as a unit. The remaining experiments have the same calorimeter range as the first six. Taking account of these facts, the fractional deviations of the experiments from Regnault's formula are as given below:

	t			t			t	
1	88·11	+·001	9	81·03	−·004	17	17·1	−·008
2	87·83	+·001	10	80·60	−·005	18	70·49	−·001
3	85·97	−·006	11	80·37	−·004	19	69·70	−·001
4	85·24	−·005	12	80·17	−·001	20	68·01	−·007
5	85·20	·000	13	79·55	·000	21	66·30	−·002
6	84·88	−·005	14	78·28	−·005	22	64·33	−·004
7	83·08	−·005	15	76·50	−·001	23	63·02	·000
8	82·66	−·001	16	71·35	−·005			

It is immediately seen that Regnault's formula gives results uniformly too great. The reason is because the formula is made to fit his experiments near 0°, which we shall see to be at fault. The average deviation of the formula from the experiments is 0·3 per cent.

The experiments near 0° are undoubtedly incorrect. They were performed by a method different from that which was used in the remainder, and Regnault himself does not consider them so good as the others, indicating a number of causes of uncertainty (Memoir, pp. 716–719). Another source of error lies in the fact that Regnault supposed, in common with the physicists of his time, that the heat necessary to form vapor depended only on the final state of the vapor and not at all on the process by which it was formed. This error did not enter into the preceding sets of experiments, for in them the process was always one of sensibly constant pressure. In the present case, in order to produce the evaporation the pressure on the liquid was reduced, and the operation was accordingly not one of constant pressure.

In place of these unreliable experiments we have the recent accurate work of Dieterici. He found for the latent heat at 0° the value 596·8, the unit being c_{0-100}. This is the result of a very careful investigation. He made first a series of eight experiments, L varying from 595·74 to 597·29. He then made a better set, three in number, the extremes being 595·98 and 596·63. He still further improved his methods and in two experiments obtained 596·67 and 597·07. The probable error is $\pm 0{\cdot}24$ or $\pm 0{\cdot}04$ per cent. In terms of c_{15} as a unit the latent heat at 0° thus becomes 598·9. Svensson's determination is somewhat larger than Dieterici's, it being 599·92 in terms of c_{0-100} as a unit; it is probably not so correct as Dieterici's, as shown by the remarkable concordance in the observations of the latter. Both have the slight possible error due to the uncertainty of the constant of the ice-calorimeter, which we have seen to be about one-quarter of one per cent.

Griffiths' determinations were of the latent heat between 25° and 50°, the determinations at 30° and 40°·15 being made with particular care. They are as follows, the unit being c_{15}:

t	25	30	40	40·15	49·8
L	581·9	578·7	572·4	572·6	566·5

These give total heats lying considerably below Regnault's linear formula, in this respect agreeing with the experiments of Dieterici, Svensson, and those of Regnault himself from 60° to 90°. This strengthens the reliability of the formula we have formed for the region above 100°, it also lying below the linear formula. As any expression for the total heat must

satisfy Regnault's determination at 100°, this being by far the most certain of any, the possibility of a linear formula is thus precluded, although it is evidently nearly such.

If we attempt to form an expression for H to satisfy Dieterici's value at 0°, Griffiths' values from 25° to 50°, and Regnault's value at 100°, it will make $\frac{d^2H}{dt^2}$ positive instead of negative, will not agree with Regnault's determinations from 60° to 90°, and will make an abrupt break at 100° where it joins the formula for the region above 100°. If one neglects Dieterici's determination and forms a formula to satisfy Regnault's value at 100° and Griffiths' determinations, and to join smoothly with the formula above 100°, it will give a value at 0° far below Dieterici's. The writer has therefore formed the following equation, using Dieterici's value at 0°, Regnault's H at 100°, and making $\frac{dH}{dt}$ at 100° equal to that by the formula used above 100°:

$$H = 598{\cdot}9 + 0{\cdot}442\,t - 0{\cdot}00064\,t^2.$$

A comparison of Regnault's experiments with this formula follows, the fractional deviations being given:

1	+·0018	6	−·0040	11	−·0029	16	−·0031	21	+·0002
2	+·0018	7	−·0040	12	+·0001	17	−·0061	22	−·0016
3	−·0051	8	·0000	13	+·0011	18	+·0009	23	+·0025
4	−·0041	9	−·0029	14	−·0037	19	+·0009		
5	+·0009	10	−·0039	15	+·0004	20	−·0050		

The agreement is far better than by Regnault's formula. Indeed a much better agreement could not be obtained by any formula which joins smoothly with one which fits the experiments above 100°. If there is a question as to which set of experiments to fit best, those above 100° or those below, the answer is immediately those above, for not only are the experiments below 100° in less concordance with one another, as shown by the deviations just tabulated, but Regnault himself says that they were more difficult to conduct, the boiling not taking place steadily, but in great puffs at intervals. The expression for H will be considered only as provisional, however; the subject of total and latent heats below 100° will be discussed again in another paper. The formula does not agree any too well with Griffiths' latent heats (adding to them h), the fractional deviations of the latter from the former being about −·005.

It should be observed that this formula, as well as the formula for total heats above 100°, holds independently of the judgment made that Regnault's calorie is equal to the specific

heat at 15° according to Rowland. For since we know the value of the mean specific heat from 0° to 100° in terms of Regnault's calorie by Regnault's own experiments, it follows that 598·9 expresses Dieterici's determination at 0° in the same unit as that in which 636·7 expresses the total heat at 100°, be that unit c_{15} or not. Therefore the writer considers that the formula expresses the total and latent heats in Regnault's calorie with a maximum possible error of 0·5 per cent at the lower end.

Griffiths believes that the mean specific heat from 0° to 100° is almost exactly equal to c_{15}. He bases this conclusion on the following considerations: He has expressed in terms of c_{15} his latent heats, already referred to, very closely by the linear formula

$$L = 596{\cdot}73 - 0{\cdot}6010\,t.$$

Extrapolating to 0° and 100° there are obtained 596·73 and 536·63. The first is almost exactly the value of L Dieterici has found at 0° in terms of c_{0-100}, the second is what one would get from Regnault's experiments on total heat if one supposed that c_{0-100} is equal to c_{15} and that Regnault's total heat at 100° is expressed also in terms of c_{15}. Thus to support a linear formula, which type of formula is improbable in itself, he has to make two suppositions, one that c_{0-100} is the same as c_{15}, which we have seen is not the best value, and the other that Regnault's calorie is equal to c_{15}, which we have seen to be probably true. But these two assumptions are contradictory, for by Regnault's own experiments on the specific heat of water c_{0-100} is 1·00358 times his calorie.

From the formulæ for h and H the writer has obtained the latent heats and thence the specific volumes of dry saturated steam. In obtaining the latter there are also required the specific volumes of liquid water at various temperatures, the relation between the pressures and temperatures of dry saturated steam, and the value of the mechanical equivalent of heat. The specific volume of water below 100° is for as many decimal places as have been used constantly 0·001 cubic meters per kilogram. Above 100° Hirn's* formula has been adopted. For the relation between pressure and temperature Regnault's formula H has been used above 100°, while below 100° his formula C (with the constants as recalculated by Zeuner) is taken. These should be sensibly correct except below 40°, where an error exists due to the fact that Regnault did not know of the sudden change in $\frac{dp}{dt}$ at 0°. The value of the mechanical equivalent is taken as 427·03 kilogrammeters (at

* Ann. de Chimie et de Phys. (4), x, p. 32, 1866.

Paris) at 15° C., according to Rowland. This determination has been strongly corroborated by recent experiments.* The volumes follow:

t	0	10	20	30	40	50	60
V	208·94	107·88	58·505	33·198	19·637	12·063	7·6703
t	70	80	90	100	110	120	130
V	5·0320	3·3942	2·3464	1·6587	1·1973	0·88099	0·65948
t	140	150	160	170	180	190	200
V	0·50152	0·38707	0·30278	0·23982	0·19216	0·15566	0·12739

Consider the possible errors in these. They may first have an error of not exceeding one-half of one per cent due to the determination of Regnault's calorie in kilogrammeters; however much this may be, it is constant for all the V's. Aside from this there may be an additional error due to our uncertainty as to the latent heats. This amounts to $\pm 0{\cdot}6$ per cent at 200°, is practically zero at 100°, and is $\pm 0{\cdot}5$ per cent at 0°. Below 40° the V's are entirely uncertain owing to the errors there in p and $\frac{dp}{dt}$ already mentioned.

In volumetric experiments on steam there is an unusual amount of difficulty on account of condensation on the walls of the vessel containing it. This condensation increases very rapidly as the saturation line is approached, and as a consequence all direct determinations of saturation volumes are far less reliable than those calculated from the latent heats, for Regnault so arranged his experiments that this source of error was entirely avoided. An exception should be made of the determination of the volume at 0° by Dieterici,† in which more confidence can be placed, not only from the concordance of his results, but also from the fact that corrections were made for condensation.

On superheated steam experiments have been made by Regnault,‡ Fairbairn and Tate,§ Hirn,‖ Horstmann,¶ Herwig,** Meyer,†† Battelli,‡‡ and Ramsay and Young.§§ A large number of observations prior to Regnault's are not included here; these are all at very low pressures, hence large volumes, for which the substance can be treated as a perfect gas.

* Johns Hopkins Univ. Circular No. 135, June, 1898, p. 54.
† Wied. Ann., xxxviii, p. 1, 1889.
‡ Mem. of the Inst. of France, vol. xxi, p. 700, 1847.
§ Phil. Trans., clii, p. 591, 1862.
‖ Théorie Mécanique de la Chaleur.
¶ Liebig's Annalen. Supplemental Band, vi, p. 51.
** Pogg. Ann., cxxxvii, p. 592, 1869.
†† Chem. Berichte. 1877, p. 2068.
‡‡ Mem. R. Acc. Sc. Torino, (2), xliii, 1893.
§§ Phil. Trans., clxxxiii A, p. 112, 1892.

For comparison of the experiments the following principles have been used: $\frac{pv}{T}$ should never exceed its limiting value for indefinite superheating; for two experiments in which the pressures and temperatures do not differ much, $\frac{pv}{T}$ should be almost the same (it would be constant for a perfect gas); $\frac{pv}{T}$ at constant pressure should be greater at greater volumes or temperatures, at constant volume it should be greater at greater temperatures or pressures, and at constant temperature it should be greater at greater volumes or lower pressures. The best determination of the limiting value of $\frac{pv}{T}$ as calculated from the chemical composition of water is that given by Van Laar,* but since he places the absolute zero at $-273°{\cdot}2$ C. instead of $-273°{\cdot}7$, the writer has modified his value to correspond, the number obtained being 3·4673, under the assumption that p is in millimeters of mercury and v in cubic meters per kilogram.

In this manner the writer has made careful comparisons of the various experiments. Those of Regnault were all at such low pressures that the substance should behave as a perfect gas, which probability is well corroborated by them. The single determination of Meyer is evidently incorrect, as it gives a value of $\frac{pv}{T}$ of 3·472 in a region where the deviation from a perfect gas should be fully two per cent.

The experiments of Fairbairn and Tate have in general pressures far lower than those of the others, but temperatures nearly as high; accordingly $\frac{pv}{T}$ should be much greater, whereas it runs far less. Of their twenty-three experiments six are comparable by the preceding principles with those of Hirn, Horstmann, Herwig and Battelli, four more with those of Hirn, Horstmann and Herwig, four with Herwig and Battelli, and four either with Herwig or Battelli. In almost every case the values of $\frac{pv}{T}$ run from two to five per cent less than they should for any agreement whatsoever, and accordingly there must have been considerable condensation.

Hirn's experiments yield great discrepancies among themselves. In seven of his twenty-two experiments, in which $\frac{pv}{T}$ should steadily increase, the values run

3·376 3·390 3·366 3·367 3·337 3·345 3·398

* Zeitschr. für Phys. Chem., xi, p. 433, 1893.

Similarly the numbers should increase in each of the following columns :

3·347	3·341	3·350	3·361
3·382	3·350	3·382	3·362
3·392	3·286	3·355	3·345
3·362	3·361	3·337	

There are a few other discrepancies, but these involve one-half of his experiments, and it is difficult to get any concordance by throwing out a few of the experiments. That there was a tendency towards condensation is shown by the fact that in four of his experiments the value of $\frac{pv}{T}$ is less than is given by the saturation line for the same pressure, the difference being more than can be allowed by any error in the latter.

Suppose we ascribe these discrepancies to condensation, throwing out accordingly about nine experiments. The remainder are so few that they are only useful as a corroboration of others. Three of them are comparable with both Horstmann and Battelli and deviate from Horstmann about one per cent, from Battelli about one-half per cent, and this is in a region where the deviation from a perfect gas is only about $2\frac{1}{2}$ per cent. Five others are comparable with Battelli. Of these two are in agreement, one deviates about $\frac{1}{2}$ per cent, and the other two deviate 2 per cent. In the last two the total deviation from a perfect gas is about 6 per cent.

Of Horstmann's four experiments one is shown to be incorrect by a comparison with the others. The remaining three agree fairly well with Battelli.

Herwig himself discards fifty-five of his seventy-five experiments as showing condensation due to too near an approach to the saturation line. Of the remaining twenty, fourteen are in a region where the substance should behave sensibly as a perfect gas. Of the other six, five are comparable with Battelli. Two are in agreement, while the other three give deviations of 0·6 per cent, 1 per cent, and 2·5 per cent.

We thus see as general conclusions from the foregoing that among the experiments of Regnault, Fairbairn and Tate, Hirn, Horstmann, Herwig and Meyer, we have available thirteen by Hirn, three by Horstmann, and six by Herwig. So many of Hirn's and Herwig's had to be thrown out as to render the others doubtful, but even accepting them we have found that in the only comparisons which can be made, those of Horstmann and Hirn, there is some disagreement, and the experiments are not sufficiently numerous to give an accurate idea of the deviation of steam from a perfect gas in various regions. Nor are they useful as corroboration of Battelli's experiments,

for of the twenty-two only seven agree with his, six are not comparable, four disagree slightly, and five disagree completely.

We have thus left only the experiments of Battelli and those of Ramsay and Young. Some at least of the determinations of the former at low pressures are incorrect, for they give values of $\frac{pv}{T}$ which differ too much from a perfect gas. In the case of Ramsay and Young we are confronted by a difficulty at the very start. I take the following quotation from them (reference, p. 122):

"The weight of the water in the tube was ascertained by determining the products of pressure and volume, altering the volumes; and this was repeated at different temperatures. Assuming that if these products for any one temperature were constant, the density of the steam was constant, viz: the theoretical density, 9, the weight could be ascertained by the equation

$$W = \frac{\text{Vapor density} \times p.\ v \times 273}{11{\cdot}1636 \times 1000 \times 760 \times (273 + t)}.$$

This expression simplifies to

$$\log W = \log p.\ v + \bar{4}{\cdot}46179 - \log (273 + t).$$

"During the progress of the experiments it happened that a trace of water passed up the tube, adding itself to that already present. This, of course, increased the weight, hence new measurements were made to determine the amount of the increase."

Thus were made the determinations of the weight of water in the tube, one the mean of experiments where the temperatures were 220° and 230°, the pressures ranging from 2500^{mm} to 3800, in the second the temperatures were 230°, 240° and 250°, the pressures ranging from 2600 to 4000, and in the third the temperatures were 250°, 260°, and 270°, the pressures ranging from 2800 to 4300. Now evidently at such pressures and volumes (the greatest specific volume came out 0·676) it is impossible that the steam can be in the condition of a perfect gas, and accordingly the determination of the weight in each of the three series is incorrect, and the volumes given by Ramsay and Young should be diminished. The errors in the three sets are probably very close to the same amount, for although the increase in temperature would mean a decrease in the error due to the assumption that the steam comported itself as a perfect gas, nevertheless the specific volumes in the three sets used for the determination of the weight diminished enough to offset this.

Assuming then this constant error in Ramsay and Young's determinations, let us make a comparison of such of them as

lie near Battelli's with his. Below is given a table of the fractional deviation, d, of $\frac{pv}{T}$ according to Battelli from that according to Ramsay and Young; in each case the experiments compared had very nearly the same values of p and T. Above each value of d is given a number for reference.

No.	1	2	3	4	5	6	7
d	+·009	+·006	+·020	+·021	−·006	+·003	+·005
No.	8	9	10	11	12	13	14
d	+·010	+·027	+·090	−·017	−·013	−·016	−·015
No.	15	16	17	18	19	20	21
d	−·014	−·007	+·013	−·021	−·019	−·020	−·017
No.	22	23	24	25	26	27	28
d	−·012	−·020	−·023	−·030	−·012	0	+·009

Nos. 2, 3, 4 were all at one temperature, about 150° C., while 5 to 11 were at 180°, 11 to 18 at 200°, and the remainder at 230°.

The sudden changes in the values of d in 9 and 10 from those in 5 .... 8, in 16, 17 from those in 11 ... 15, and in 26, 27, 28 from those in 18 .... 25, can all be accounted for by condensation, since Ramsay and Young's figures, as will be shown, give marked evidence of condensation as the saturation line is approached, while those of Battelli do not. But the remarkable fact is that in the first eight, with the exception of the fifth, the deviations of Battelli from Ramsay and Young are all positive, the reverse of what is due to the error in the latter already mentioned. Suppose we ascribe this to large condensation in the case of Ramsay and Young. Looking at 11 .... 28 we see that the constant error in their experiments must amount to 1·5 per cent, hence in the first eight there must have been condensation to the amount of 2·5 per cent.

But there are a few experiments below 100° which can be compared, and in that region Ramsay and Young's experiments do not have the constant error already mentioned, the weights being measured directly. These follow:

	Ramsay and Young.			Battelli.		
p	45·47	39·95	35·3	67·57	85·32	100·27
v	26·06	30·15	33·57	17·851	14·1326	12·0335
T	348·7	348·7	348·7	352·24	352·24	352·24
$\frac{pv}{T}$	3·415	3·454	3·399	3·424	3·423	3·422

Now Ramsay and Young observed that there was far more condensation below 100° than above, so much so that they themselves admit that the larger part of their low temperature

determinations are worthless. Therefore those given above should have at least 2·5 per cent condensation; hence, Battelli's determinations being correct, $\frac{pv}{T}$ by Ramsay and Young should be, perhaps not 2·5 per cent smaller than by Battelli, for the latter's volumes are smaller, but certainly 1·5 per cent smaller. Instead of that the smallest of Ramsay and Young's is only 0·8 per cent smaller than the greatest of Battelli's, while one of them is larger than any of the latter. We thus see that the supposition that the deviations in 1 . . . . 8 are due to condensation on the part of Ramsay and Young involves us in difficulties. At any rate they show conclusively that in the region considered either Ramsay and Young or Battelli is entirely in error.

Further, Ramsay and Young's experiments 11 . . . . 28 have all the same weight of water with the exception of Nos. 20 and 22, and hence should have a practically constant deviation to check with Battelli's. Nos. 11 . . . . 15 have such a constant deviation of about 1·5 per cent, while Nos. 18, 19, 21, 23 . . . . 26 have a fairly constant deviation of about 2 per cent, different from the former. Hence we see that the two investigations are entirely out of accord. One of them is incorrect, perhaps both.

We will therefore next examine Ramsay and Young's experiments by themselves. First they discard all their experiments below 75° C. as untrustworthy. At 75° their determinations show consecutive variations as high as 1·6 per cent. Above 100° C. there was a great deal of condensation in every case as the saturation line was approached; this is shown by the rapid increase of vapor density with increasing pressure. Thus at 140° C. total condensation occurred at a pressure of 2645^{mm}; the saturation pressure for that temperature is 2717. At 150°, 160°, 180°, 190° and 200° total condensation occurred at pressures of 3442, 4571, 7444, 9337 and 11505^{mm} respectively; the corresponding saturation pressures are 3581, 4651, 7546, 9443 and 11689^{mm}. Aside from this the density showed an impossibly rapid increase before condensation.

There are some other discrepancies in Ramsay and Young's observations which will merely be mentioned. Thus if comparison is made of those experiments at temperatures 270°, 260° and 250° for which the volumes are given as 0·644, 0·585, 0·529, and 0·435, it will be found that at constant volume $\frac{pv}{T}$ decreases with increasing temperature, which is impossible. The experiments below 250° at these same volumes, as well as at others, make $\frac{pv}{T}$ at constant volume increasing with increas-

ing temperature, which is correct; but the increase is so rapid as to look a little suspicious. According to Battelli the increase is very slow.

Even if Ramsay and Young's experiments are substantially correct far from the saturation line, they cannot be used, for they contain a constant error, the incorrect determination of the weight of water present in the tube. There is no agreement with Battelli by which this error can be estimated, nor can we determine it from our saturation volumes already obtained, since in Ramsay and Young's experiments near the saturation line great condensation occurred.

We have left therefore only Battelli. In a table below is given a comparison of $\frac{pv}{T}$ according to such of his experiments as lie near the saturation line with that according to Regnault's experiments, the volumes being calculated from the latent heats. Each of the latter is given immediately under that one of Battelli's which is to be compared with it, and the fractional deviation of $\frac{pv}{T}$ is given last.

p	129·14	330·78	749·12	2060·1	3061·9	7971·4	12181·
T	330·7	352·2	373·33	404·01	417·94	456·6	475·71
$\frac{pv}{T}$	3·413	3·411	3·392	3·373	3·350	3·276	3·210
p	148·79	354·62	760	2030·3	2717·6	7546·4	11689
T	333·7	353·7	373·7	403·7	413·7	453·7	473·7
$\frac{pv}{T}$	3·420	3·403	3·373	3·317	3·294	3·196	3·143
d	−·002	+·002	+·006	+·017	+·017	+·024	+·021

It is at once seen that the discrepancy is very bad. Were the deviations negative instead of positive they could be ascribed to condensation in the case of Battelli, and his experiments not near the saturation line would still be available. Let us now see, supposing Battelli to be correct, where an error in our saturation volumes can be placed. We have seen that the greatest error which can possibly be ascribed to the mechanical equivalent of Regnault's calorie is 0·5 per cent. This would make the deviations respectively

−·007 −·003 +·001 +·012 +·012 +·019 +·016

Further we have seen that the latent heat at 200° C. may be at most 0·6 per cent too small, although at 100° C. it is correct. Allowing errors in the latent heats the deviations become

−·007 −·003 +·001 +·010 +·010 +·014 +·010

The two negative ones, at low pressures, could be ascribed to

condensation on Battelli's part, but the remainder of course cannot.

So far we have assumed Regnault's p and $\frac{dp}{dt}$ to be correct, and we see it is impossible to get any agreement with Battelli. If we allow an error in Regnault's p and $\frac{dp}{dt}$, we must take them according to the formula Battelli gives to fit his own experiments on corresponding saturation pressures and temperatures, for we are going on the supposition that his work is correct. The change in $\frac{dp}{dt}$ changes the saturation volumes, so $\frac{pv}{T}$ is doubly changed. The deviations then become

+·023 +·006 +·018 0 +·007 +·013 +·019

and things are made worse rather than better.

It is thus a question of whether to discard Regnault's data entirely, or Battelli's. Regnault's results, with the exception of total heats at low temperatures, have received essential corroboration from almost every one who has gone over the same ground, and this is especially so concerning saturation pressures and temperatures. On the other hand, Battelli's saturation pressures deviate considerably from those of all other observers, we have seen that in some of his volumetric experiments at low pressures errors exist, and that finally there is practically no corroboration between his volumetric experiments and those of other investigators.

The writer therefore concludes that all our knowledge concerning the density of steam is limited to the saturation line, the experiments on superheated steam presenting discrepancies which cannot be reconciled.

ART. V. — *The Estimation of Boric Acid;* by F. A. GOOCH and LOUIS CLEVELAND JONES.

[Contributions from the Kent Chemical Laboratory of Yale University—LXXVII.]

THE estimation of boric acid by treating the salts of that acid with sulphuric acid, distilling with methyl alcohol, evaporating the distillate over magnesium oxide, igniting and weighing, was proposed by Rosenbladt.* A little later, and without knowledge of Rosenbladt's experience, a somewhat similar process,† which consisted in the treating of the compound of boric acid with acetic acid or nitric acid, distillation with methyl alcohol, evaporation of the distillate over calcium oxide, and ignition of the residue, was described by one of us. In the course of the development of this process, it transpired that the insolubility of magnesium oxide retards the absorption of boric acid by that substance, and that the more soluble calcium oxide retains boric acid more actively and is therefore to be preferred.

Points in the treatment upon which special emphasis was laid in the original description of this process were the choice of a suitable apparatus for the distillation, the employment of a loosely stoppered receiver for the reception of the distillate upon slaked lime, the careful removal of water from the substance in the retort before acidifying and treating with the methyl alcohol, regulated use of acid, and care in the evaporation and ignition.

The attainment of good results in this process depends upon attention to details. Modifications have been suggested by several investigators. Thus, instead of igniting the calcium oxide in a large platinum crucible, transferring it to the receiver to hold the boric acid, and returning the calcium oxide with the distillate to the same crucible for subsequent ignition of the residue, as was originally proposed, Penfield‡ prefers to ignite the calcium oxide in a small crucible, to collect the distillate in ammoniacal water, to evaporate the latter over the calcium oxide in a large platinum dish, and to transfer this residue back to the small crucible for the final evaporation and ignition. Kraut§ suggests a modification of form in the apparatus with no other essential change in conditions. Moissan‖ has suggested changes in the apparatus and avoids a transfer of the calcium oxide—collecting the distillate by itself in a closed receiver, trapped with an ammonia bulb to prevent the escape of the boric acid from the distillate. Furthermore, Moissan's process calls for the use of an amount of calcium oxide from fifteen to twenty times greater than that theoretically required.

* Zeitschr. für Anal. Chem., xxvi, 21. † Am. Chem. Jour., ix, 23.
‡ This Journal, xxxiv, 222. § Zeitschr. für Anal. Chem., xxxvi, 3.
‖ Compt. Rend, cxvi, 1084.

From our experience it seems obvious that the demand for this amount of calcium oxide arises from an excessive use of nitric acid in the retort and the consequent modification of conditions in the distillate. Fortunately this difficulty may be avoided by the use of a little phenolphthalein as an indicator in the retort and care to limit the addition of nitric acid to the amount required to produce distinct acidity. The addition of a drop of the acid and another of the indicator should be repeated once or twice during the distillation to insure the replacement of the acid volatilized from the salt slightly decomposed in the process. The effect of much nitric acid is bad, not only because it neutralizes the calcium oxide when it passes to the distillate, but because when it is used a tendency is developed on the part of the dried mixture of calcium hydroxide and borate to puff explosively if this ignition is begun as soon as the residue is dry. If the residue is heated gradually and as strongly as possible over a radiator before the flame is actually applied to the crucible, no such action takes place; we are disposed to attribute it to the effect of the nitrate and nitrite, produced by the absorption of nitrous fumes in the lime, upon the alcohol or other organic matter retained by the lime in the evaporation and drying unless the latter process is prolonged at high temperature.

That good results may be obtained with small amounts of calcium oxide provided care as to the use of nitric acid and the conditions of ignition be taken, is shown by the figures of the original description and by the following experiments, in which phenolphthalein was employed as an indicator and the residue heated strongly over the radiator before actual ignition.

CaO taken. grm.	B_2O_3 taken. grm.	B_2O_3 found. grm.	Error. grm.
2·3405	0·1788	0·1792	+0·0004
1·7620	0·1790	0·1785	−0·0005
2·1757	0·1824	0·1840	+0·0016
2·5656	0·1788	0·1786	−0·0002

These results are accurate within reasonable limits. On the other hand, without care to ignite gradually we have noted errors of from 0·0030 grm. to 0·0060 grm. in the process otherwise conducted similarly. Doubtless the use of large amounts of calcium oxide as suggested by Moissan may serve the purpose of diffusing the explosive mixture through a mass of inert matter sufficient to prevent violent puffing, but care to heat over the radiator as strongly as possible before opening the flame directly to the crucible answers the same end. The difficulty does not exist when acetic acid is used in place of nitric acid, though even in this case it is safer to use the radiator in the first stages of heating, thus avoiding the danger of mechanical loss by too rapid ignition.

Following are determinations made by this method with the use of acetic acid.

CaO taken. grm.	B_2O_3 taken. grm.	B_2O_3 found. grm.	Error. grm.
0·9977	0·2065	0·2062	−0·0003
1·0220	0·2067	0·2070	+0·0003
1·3717	0·2077	0·2075	−0·0002
1·1310	0·1791	0·1795	+0·0004

The results of the preceding table, as well as those of the investigators mentioned, are a sufficient answer to the criticism of Reischle,* that acetic acid and nitric acid do not liberate boric acid in the distillation process so that good results may be obtained. Moreover, it has been shown by one of us† that even carbonic acid is strong enough to bring about complete volatility of boric acid with methyl alcohol.

The use of Calcium Oxide as a Retainer.

Quite recently Thaddeeff‡ has advocated the abandonment of calcium oxide as an agent for holding boric acid in the evaporation of alcoholic and aqueous solutions on account of the hygroscopic nature of the oxide and the consequent difficulty of securing it in definite conditions for weighing, and proposes, instead of using calcium oxide, to retain and estimate boric acid in solution by converting it into the form of potassium borofluoride.

In the final modification of Thaddeeff's method the proposal is made to liberate the boric acid from its compounds by sulphuric acid, to volatilize it in methyl alcohol with the aid of a current of dry air, to catch the distillate in potassium hydroxide, to treat the mixture of hydroxide and borate with hydrofluoric acid in excess and evaporate in the steam bath, to digest the residue of fluoride and borofluoride at normal temperatures for two hours with 50^{cm^3} of a potassium acetate solution (sp. gr. 1·14) and for twelve hours more after adding 100^{cm^3} of ethyl alcohol (sp. gr. 0·805), to filter on paper, wash the residue with $62–72^{cm^3}$ of alcohol (sp. gr. 0·805), dry at 100° and weigh as potassium borofluoride, after which the borofluoride is to be dissolved in boiling water and tested with calcium chloride for possible contamination by the presence of a fluoride. Plainly Thaddeeff's procedure presents at the outset difficulties; for besides the inconvenience of conducting long digestions with reagents of regulated strength, the difficulty of procuring hydrofluoric acid free from silica, which if present (as it usually is, in the so-called chemically pure hydrofluoric acid of commerce) would be retained in the borofluoride as potassium

* Zeitschr. für Anal. Chem., xxvi, 512.
† Jones, this Journal, v, 442.
‡ Zeitschr. für Anal. Chem., xxxvi, 568.

fluosilicate, the inaccuracy of the dried paper filter, and the obvious uncertainty of success in an attempt to wash a mixture of acid potassium fluoride and potassium borofluoride in potassium acetate and alcohol, so that the one shall be rendered entirely soluble while the other remains sensibly unaffected,—besides these objections, there is the theoretical probability that boric acid must be lost by volatilization during the evaporation of the solution of the mixed salts in the presence of free hydrofluoric acid. This last point was put to the proof by submitting to distillation in a platinum retort a mixture of equal quantities of borax and potassium hydroxide with an excess of hydrofluoric acid, collecting the distillate in potassium hydroxide, evaporating it to dryness and testing it for the presence of boric acid. When this residue from the evaporated distillate was treated with sulphuric acid and methyl alcohol, the burning alcohol vapor gave plainly the green flame of boric acid. Another portion showed clearly the presence of boric acid when acidulated with hydrochloric acid tested with turmeric paper. No boric acid could be detected in any of the reagents used. It is plain, therefore, that boric acid does volatilize upon the evaporation of a mixture of potassium fluoride and borofluoride in acid solution. The amount of such loss is disclosed in the record of the following experiment. Portions of a standard solution of boric acid, prepared by dissolving a known weight of anhydrous boric oxide in a liter of water, were mixed with a solution of potassium hydroxide (free from silica and standardized by conversion to the chloride) in the proportions to form the potassium borofluoride, and an excess of hydrofluoric acid was added. The mixture was evaporated and the residue was dried and weighed at 100°, the whole operation being conducted in platinum.

HKF_2 equivalent to KOH taken. grm.	B_2O_3 taken. grm.	$KFBF_2$ theoretical weight. grm.	$KFBF_2$ found. grm.	Error in terms of $KFBF_2$. grm.	Error in terms of B_2O_3. grm.
0·3531	0·1582	0·5701	0·5580	−0·0121	−0·0033
0·3192	0·1430	0·5154	0·5100	−0·0054	−0·0015
0·3192	0·1430	0·5154	0·5030	−0·0124	−0·0034
0·3192	0·1430	0·5154	0·5088	−0·0066	−0·0018
0·3192	0·1430	0·5154	0·5114	−0·0040	−0·0011

In experiments (1) to (3) the volume of the solution evaporated was about 50$^{cm^3}$. In experiment (4) this volume was reduced about one-half before acidifying with hydrofluoric acid, while in experiment (5) the solution was diluted about one-half before adding the hydrofluoric acid. It is plain, therefore, that in this single step of Thaddeeff's process there is a considerable error of deficiency. On the other hand, the errors for the full process as laid down by Thaddeeff have been in

our experience invariably differences of excess—presumably because the loss due to volatilization of boric acid has been overbalanced by the inaccuracy in washing. It is plain that the process can give true indications only by the balancing of considerable errors.

If we take into consideration, therefore, the inevitable inaccuracy and inconvenience of Thaddeeff's proposal, it cannot be regarded as a desirable substitute for the process according to which boric acid is absorbed and retained for weighing with calcium oxide, especially since the difficulties in the way of getting constant weights of that substance are by no means insuperable.

Thus the following table shows the series of weights taken in several experiments in bringing calcium oxide to a constant weight in a 50^{cm3} platinum crucible ignited over a blast lamp, as well as the weight taken after adding a known amount of standard boric acid solution to the slaked oxide, evaporating, and igniting. The results recorded are those of experiments made on days not moist beyond the average and with the greatest care to approach the limit of accuracy with which calcium oxide and the boric acid held thereby can be weighed under ordinarily favorable conditions. The first weight of calcium oxide recorded under each experiment was taken after a strong ignition over the blast lamp for about one-half hour. The succeeding weights were taken after similar ignition of five minutes. In all cases the crucible was left to stand a definite period in a sulphuric acid dessicator, and, after the approximate value had once been obtained, the weights of the preceding weighing were replaced on the balance before the crucible was taken from the dessicator. The average of the weights bracketed is the weight taken as constant for the calculations.

	CaO taken. grm.		B_2O_3 taken. grm.	$CaO + B_2O_3$ taken. grm.	$CaO + B_2O_3$ found. grm.		Error. grm.
	0·9505				1·1590		
(1)	0·9493	0·9493	0·2095	1·1588	1-1591	1·1591	+0·0003
	0·9493						
	1·1319				1·3499		
	1·1317				1·3474		
(2)	1·1313	1·1315	0·2150	1·3465	1·3475	1·3475	+0·0010
	1·1315				1·3476		
	0·8028				0·9205		
(3)	0·8025	0·8024	0·1184	0·9208	0·9206	0·9206	+0·0002
	0·8024				0·9206		
	2·6980						
(4)	2·6975				2·9043		
	2·6973	2·6973	0·2073	2·9046	2·9049	2·9048	+0·0002
	2·6973				2·9044		

Obviously calcium oxide may be weighed with accuracy, with or without boric acid; but the fact remains that a less hygroscopic absorbent—one requiring less care in the handling, is to be desired.

The use of Sodium Tungstate as a Retainer.

In searching for a suitable material of less hygroscopicity to replace calcium oxide as a retainer for boric acid, we have found that sodium tungstate, fused with a slight excess of tungstic acid over that contained in the normal tungstate (to insure its freedom from carbonate), answers this purpose excellently. This substance is definite in weight, not hygroscopic, soluble in water, and recoverable in its original weight after evaporation and ignition. To test its value as a retainer for boric acid, portions of it—4 to 7 grms.—were fused and weighed in a 50^{cm^3} crucible, the tungstate was dissolved in water and to it was added a known amount of a standard solution of boric acid. After diluting, mixing, evaporating, and fusing the residue, the increase in weight should represent the boric anhydride held by the tungstate. The results of the accompanying table show how accurately the boric acid is retained under these conditions: In experiments (3) to (7) the tungstate, after its first weighing, was dissolved, transferred to a larger platinum dish and mixed therein with the boric acid. After evaporation to a suitable volume this solution of tungstate and boric acid was transferred to the original crucible for final evaporation and ignition.

$Na_2WO_4 + WO_3$ taken. grm.	B_2O_3 taken. grm.	B_2O_3 found. grm.	Error in B_2O_3. grm.
6·5416	0·1784	0·1771	−0·0013
7·3134	0·1786	0·1773	−0·0013
5·5003	0·0950	0·0952	+0·0002
4·1394	0·0944	0·0944	0·0000
7·5037	0·2148	0·2149	+0·0001
4·7744	0·2718	0·2702	−0·0016
6·6470	0·2503	0·2487	−0·0016

It is plain that though the sodium tungstate does not hold the boric acid with absolute accuracy the errors are not unreasonable −0·0008 grm. in the mean. Upon substituting the tungstate for calcium oxide as a retainer in the distillation process, the results were likewise highly favorable.

We used by preference the apparatus originally proposed, excepting that the Erlenmeyer flask used as a receiver is fitted tightly to the condenser and trapped with water bulbs. The retort is made very easily from a 150^{cm^3} pipette and has the special advantage that particles of the residue spattering dur-

ing distillation are easily washed from the walls of the vessel by a slight rotary motion of the retort. It was found that special care should be taken to give the tungstate ample time for contact with the distillate before exposing the latter to atmospheric evaporation. The distillate was received, therefore, in a dilute solution of sodium tungstate placed in the receiver, cooled by ice and trapped with water, and the mixture was well stirred, allowed to stand one-half hour, evaporated to small volume in a large dish, and transferred to the crucible in which the tungstate had been originally weighed. After thorough drying the residue was ignited to fusion and weighed. When acetic acid was employed in the retort, care was taken in the ignition to expose the fused mass freely to the air (by causing it to flow upon the sides of the crucible) until the color of the cooled tungstate was white, in order that the reducing effect of the acetate might be eliminated. In the experiments recorded in the following table the tungstate was used in the receiver to retain the boric acid distilled as usual with methyl alcohol, from the borates treated with acetic acid, nitric acid or sulphuric acid, in amounts regulated by the use of phenolphthalein as an indicator.

$Na_2WO_4 + WO_3$ taken. grm.	B_2O_3 taken. grm.	B_2O_3 found. grm.	Error grm.
	With Nitric Acid.		
8·5516	0·1582	0·1572	−0·0010
4·9639	0·1329	0·1323	−0·0006
8·0033	0·1267	0·1256	−0·0011
	With Acetic Acid.		
4·9658	0·1434	0·1418	−0·0016
6·0289	0·1431	0·1433	+0·0002
4·6797	0·1589	0·1587	−0·0002
4·0013	0·1433	0·1422	−0·0011
	With Sulphuric Acid.		
6·3439	0·1582	0·1579	−0·0003
8·8227	0·1582	0·1577	−0·0005
10·1516	0·1265	0·1264	−0·0001
6·5738	0·1392	0·1390	−0·0002

Excessive use of acid is disadvantageous, and this is especially true in the case of sulphuric acid; for, if this acid is carried over with the methyl alcohol, as it is at 100° if present in appreciable excess, a part of it, at least, is held permanently by the tungstate to increase the apparent weight of the boric acid to be estimated.

The manipulation of the tungstate presents no difficulties, and the results obtained by its use are reasonably accurate.

ART. VI.—*Descriptions of imperfectly known and new Actinians, with critical notes on other species*, II.; by A. E. VERRILL. *Brief Contributions to Zoology from the Museum of Yale College*, No. LIX.

Family HALOCLAVIDÆ Ver. nov.

COLUMN much elongated, either smooth or with suckers; base with a very small or rudimentary disk; tentacles 20, obtuse or capitate; ten pairs of mesenteries, all perfect.

Haloclava, gen. nov. Type *H. producta* (Stimp.) Ver. Figure 7.

Column much elongated, soft, without a sheath, the upper part with rows of distinct adhesive suckers. Upper end with a sphincter and capable of involution. Aboral end often inflated or bulbous, with a rudimentary disk, capable of adhesion to small pebbles. Tentacles twenty, short, usually clavate, nearly equal, marginal. Mesenteries very muscular, all perfect,

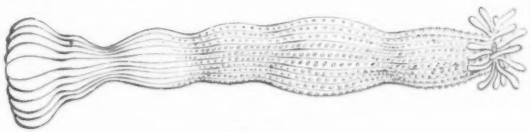


Fig. 7.

arranged in 10 pairs; six of these pairs are larger and form a regular primary cycle; four other pairs, narrower below, belong to the second cycle; the usual pair, next to the ventral or sulcar pair of directives, is lacking on each side.

Besides the type species this genus will include *H. albida* Ver., which I now consider only a variety. *H. Capensis* Ver., Commun. Essex Inst., v, p. 5, pl. 3, fig. 7, 1869;* *H. brevicornis* (Stimp.) Ver., op. cit., p. 4, pl. 3, figs. 2, 2^a, 2^b; and *H. Stimpsoni* Ver., op. cit., p. 5, pl. 3, fig. 1, 1869, resemble this genus but probably belong to *Eloactis* Andres. No specimens

* Andres, in his classical work on the Actinaria, has entirely overlooked my two illustrated articles on Actinaria of the North Pacific Expl. Expedition, in the Comm. Essex Inst., vols. v and vi, 1868, 1869, quoted above, and has, therefore, omitted one of the above named species from his work, as well as numerous other species and several genera first described and illustrated in those papers. In several cases he stated that no figures nor descriptions of certain species therein described had been published. Nevertheless he quotes those papers in his bibliography. In the papers referred to there are four plates of Actiniæ (40 figures). He also failed to quote several other papers by me. Among those omitted are Report on Invert. of Vineyard Sound, etc., 1874; Radiata from Coast of North Carolina, this Journal, iii, p. 432, 1872; Bulletin, U. S. Nat. Mus., No. 15, 1879; American Naturalist, ii, p. 251, and several others. He intended to include all the literature and all known species. Such omissions are liable to happen in the best works.

of either species were preserved by Dr. Stimpson. His original drawings show no suckers.

H. producta ranges from S. Carolina to Cape Cod. *Var. albida*, Cape Cod.*

Eloactis brevicornis and *E. Capensis* are from Cape of Good Hope.

E. Stimpsoni, Hong Kong, China.

Family Bunodactidæ Verrill = *Bunodidæ* Gosse.

Bunodactis V., new name = *Bunodes* Gosse (restr.)

Bunodes (*pars*) Gosse, 1855, 1860, *not* of Eich. (genus of Eurypteroidea), 1854.

Unfortunately the name *Bunodes* was preoccupied,† as indicated above, for a genus of eurypteroids, and some other name has to be chosen for this well known genus of actinians. None of the numerous groups recently established seem to correspond with this genus, and I have, therefore, given it a new name.

This genus, as now limited, includes species that have from 12 to 48 pairs of perfect mesenteries,‡ the number increasing with age. All the larger mesenteries, except the directives may bear gonads. The submarginal sphincter is prominent, endodermal and circumscribed. The verrucæ of the column are intraseptal evaginations of the wall and serve as true adhesive suckers; some of the rows may reach the base. The wall is imperforate, at least in the typical forms. The marginal tubercles are simple and similar to those below, and are not true acrorhagi, though sometimes pigmented distinctively. The wall is thick and muscular.

Bunodactis seems to include a considerable number of species, widely distributed. Among these are the following: *B. verrucosa* (Penn.) = *gemmacea* (type); *B. Balli* (Cocks); *B. Listeri* (Johns.); *B. glandulosa* (Otto) = *B. rigida* (And.); *B. thallia* (Gosse); *B. sabelloides* (Andres), all from European seas; *B. pluvia* (Dana); *B. cruentata* (Dana); *B. ocellata* (Less.), and *B. papillosa* (Less.), West S. America; *B. inornata* (Ver.) Hong Kong; and *B. Japonica* (Ver.) Japan. In accordance with the usual custom, the change in the typical generic name will make it necessary to change the family name *Bunodidæ* to *Bunodactidæ*. Tealiadæ (Hert.) might be used, were not *Tealia* a synonym of *Urticina* (Ehr., 1834, restricted).

* Andres has based a new sp. (*H. Elizabethæ*) on an incorrect outline figure of this, in a popular work. It is the same as *H. albida*.

† Eichwald, Bull. Soc. Imp. Nat. de Moscou, vol. xxvii. part I, pp. 50, 107, pl. II, figs. 2–4, 1854, *Bunodes lunula*. The article is dated, at the end, Nov. 2, 1853.

‡ Y. and A. F. Dixon (Sci. Proc. Roy. Dublin Acad., ii, p. 310) have shown that in *B. thallia* the number of mesenteries and their arrangement are remarkably variable, and that abnormal specimens are found with one or with three pairs of directives and corresponding siphonoglyphs. I have found the same variations in *B. stella*, which usually has about 24 pairs of perfect mesenteries.

Bunodactis stella Verrill.

Bunodes stella Verrill, Revis. Polyps E. coast of U. S, p. 16, pl. I, figs. 1–8, 1864; Amer. Naturalist, II, p. 258, 1868.

Bunodes spectabilis Verrill, Check List Mar. Invert. N. New Eng., p. 15, 1879; Cont. to Nat. Hist. of Arctic America, in Bulletin U. S. Nat. Mus., No. 15, p. 152, 1879 (*non* Fabr.).

Bunodes (?) stella Andres, Attinie Golfes von Neapel, p. 230, 1884. McMurrich, Actinaria of Bahama Is., p. 30, 1889.

Having received large specimens of this species from Greenland and Cumberland Gulf, I at one time identified it with *A. spectabilis* Fabr., owing mainly to the green color of the latter, but as this was not described as verrucose, it is more probable that it was the green variety of *Urticina crassicornis*, which also occurs in Greenland. At Eastport, Me., between tides, a common variety of the latter is green mottled more or less with red or brown.

This species is a true Bunodes, closely related to the common European species (*B. verrucosa*), as stated in my detailed description in 1864. It is somewhat singular that Andres, with my full description and figures, should have put it as a doubtful species, even suggesting that it might belong to *Aulactinia*, a genus established by myself for a species described in the same paper with the present one, as if I did not know the characters of my own genera and species!

McMurrich simply followed Andres in expressing this doubt, but regretted that he could not obtain examples for study, after futile efforts. It is, however, a very abundant species at low-water mark at Eastport, Me., and numerous specimens have been preserved by me for the Mus. Comp. Zool. (including the original types); the U. S. Nat. Mus.; the Mus. of Yale University, etc. He certainly did not ask me for specimens.

He also described a very different species, from the Bahamas, for which he proposed the provisional name of *Aulactinia stelloides*, but he, at the same time, expressed the opinion that it might prove to be identical with *B. stella*.

Mr. Duerden (Journ. Inst. Jam., ii, p. 454, 1898), misled by this statement, went farther and definitely united the same species, from Jamaica (as *Aulactinia stella*), with my *B. stella*. The latter is a very arctic littoral species, ranging from Maine to Greenland. Its occurrence as a littoral species in the West Indies would, of itself, be a case without parallel. The West Indian species probably belongs to a different genus, but it does not agree with the characters of typical *Aulactinia*.

For such species I propose the name *Bunodella*.

Bunodella V., gen. nov. Type *B. stelloides* (McMur.)

Form of body and tentacles same as in *Bunodactis*. Column with longitudinal rows of true adhesive verrucæ on the upper

part. Margin with a row of simple, round or conical verrucæ similar in structure to the others. Mesenteries in several cycles with but six perfect pairs (in the type). Submarginal sphincter well developed, endodermal, circumscribed.

Differs from *Aulactinia* in not having lobate marginal verrucæ. The structure of the column-wall is also different: From *Bunodactis* it differs, so far as known, in having but six pairs of perfect mesenteries, as in very young examples of the latter. Should larger specimens of *Bunodella* be found to have a greater number of perfect mesenteries, this group would not differ essentially from *Bunodactis*.

Anthopleura Dowii Ver. Figure 8.

Trans. Conn. Acad. Sci., i, p. 474, 1869; Andres, op. cit., p. 223, 1884 (*Dovii*).

This species was pretty fully described by me in 1869, but the anatomy was not then given.

A medium sized example, 40^{mm} across, in alcohol, has about 96 pairs of mesenteries, of which 48 are perfect and furnished with large plicated muscles along most of their breadth; a pair of very small imperfect mesenteries, without gonads, usually intervenes between each perfect pair. The mouth has two large siphonoglyphs and about 22 crenulations on each side. Sphincter muscle well circumscribed, ovate in section, not very large. Larger submarginal tubercles or actinobranchs have 4 to 6 lobules on the lower side, each with a small point, appearing as if perforated, though the openings, said to exist in life, are not visible (fig. 8). Adhesive, cup-shaped suckers, of the longer rows, reach the base. Panama to San Salvador.

Anthopleura Stimpsoni Ver., Comm. Essex Inst., vi, p. 32, 1869. Figure 9.

This species has 12 pairs of perfect mesenteries, with large muscles along most of their breadth; 12 pairs of 3d cycle, well developed; about 24 pairs of 4th cycle, of small size and barren; all the others, except directives, bear large gonads. Sphincter muscle circumscribed, rather large, ovate in section. Actinobranchs (fig. 9) crowded, three to five in the larger rows, the upper one three to five lobed or digitate, the larger lobes often subacute and perforated. Adhesive suckers large, in unequal rows. Hong Kong, China. Type.

Bunodosoma, gen. nov. Type, *B. granulifera* (Les.).

General form and appearance as in *Bunodactis*, but the hollow verrucæ, arranged in vertical rows, are rounded or subconical and do not form adhesive suckers. Upper or submarginal ones are larger and in mature specimens more or less

lobulated, but have nearly the same structure as those below, though they are described as perforated when living. Tentacles numerous; many mesenteries, 12, 24, or more pairs being perfect. Sphincter muscle well developed, endodermal and circumscribed.

To this group I refer the following:

Bunodosoma granulifera (Les., 1817).

Aulactinia granulifera Andres, 1884, p. 221.
Bunodes granulifera Duerden. 1898, p. 454.
Bunodes tæniatus Mc Mur., 1889, p. 23.
Cereus Lessoni Duch. and Mich., 1860, p. 42.

West Indies.

Bunodosoma cavernata (Bosc, 1801).

Bunodes cavernata Ver., 1864. p. 17.
Cladactis cavernata Ver., 1869, p. 473.
Phymactis cavernata Andres, 1884, p. 231; Mc Mur., 1887, p. 51.

South Carolina to Cape Hatteras.

Various other species described under *Bunodes*, *Aulactinia*, etc., may belong here, but the descriptions of the verrucæ and other parts are insufficient to determine their position. *Aulactinia crassa* Andres looks more like *Bunodosoma* than like *Aulactinia*.

Family Phyllactidæ.

Asteractis Verrill, 1869. Type, *A. Bradleyi*.

Asteractis Verrill, Trans. Conn. Acad. Sci., i, p. 465, 1869. Andres, op. cit., p. 292, 1884.

This genus is characterized by the presence of a special wide ruffled collar outside the tentacles, covered with complex rows of compound verrucæ or lobed outgrowths,* but not forming true free fronds. The column bears more or less numerous adhesive verrucæ in rows below the collar. There are 12 or 24, or more pairs of perfect mesenteries and one, or sometimes two, endodermal sphincter muscles.

Asteractis flosculifera (Les.) Ver.

Actinia flosculifera Les., Journ. Acad. Sci. Philad., i, p. 174, 1817 (not *Oulactis flosculifera* Duch. and Mich., nor of McMurrich).
Evactis (?) *flosculifera* Andres, op. cit., p. 235.
Oulactis fasciculata McMurrich, Proc. Philad. Acad. Sci., 1889, p. 108; also in Heilprin's "The Bermuda Islands," p. 112, pl. x, fig. 5 (section), 1889.

This species is common at Bermuda, living buried to its margin in shell-sand at low-water mark. Figures from life will be published soon in Trans. Conn. Acad. Science.

* They are probably branchial in function and may be called actinobranchs (*Actinobranchiæ*). The groups that they form may be called pseudofronds.

It has been pretty fully described, as to its anatomy, by McMurrich. The collar is covered by radial pseudofronds composed of about three rows each, of lobed tubercles, the lobules being short or rounded; a single larger lobed tubercle or actinobranch occupies the distal end of each group, and a nearly simple one often forms the proximal end, next to the fosse at the bases of the tentacles. The color is variable, but the collar is usually umber-brown, varied with yellowish, flake white, and reddish brown spots.

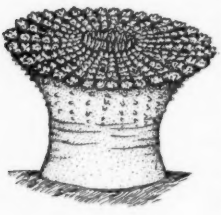
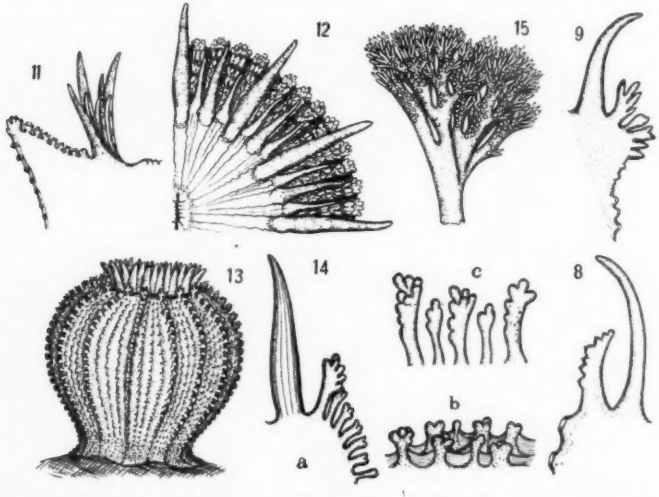


Fig. 10.

Asteractis Bradleyi Ver. Figures 10, 11, 12.

Trans. Conn. Acad., i, p. 465, 1869. Andres, op. cit., p. 292, 1884.

This is closely allied to the preceding species. The pseudofronds of the collar are made up of more finely lobulated verrucæ, so that they appear more complex. These verrucæ, in



the alcoholic specimen, are closely crowded in each radial series, of which there are 48; their upper and lateral surfaces are divided into many small rounded or conical lobules, most prominent along the outer sides and at the distal end of the last or distal one, where about five lobules project, in each group, beyond the edge of the collar, giving it a finely serrate or fringed appearance (figs. 11, 12). The verruciform adhesive suckers are in 48 rows, of 3 to 5 each, corresponding to the

pseudofronds, and extending only a short distance below the collar.

The general figure, now given, is based on a sketch from life, by F. H. Bradley, of the original type, corrected by comparison with the preserved specimen, which was from Panama.

Asteractis conquilega **(Duch. and Mich.) Ver,**

Oulactis flosculifera Duch. and Mich., Corall. Antill., p. 46, 1860 (*non* Les.); Supl., p. 129, 1866. McMurrich, Actin. Bahamas, p. 56, pl. II, fig. 2, pl. IV, figs. 12–14 (anatomy), 1889.
Oulactis conquilega Duch. and Mich., op. cit., pp. 49, 89, pl. VII, figs. 7, 11, 1860.
Oulactis foliosa Andres, op. cit., p. 290, 1884.

The collar of this West Indian species is very broad and is covered with about 24 pseudofronds, or groups of small folds and lobulated and crowded actinobranchs, much more complex than in either of the preceding species.

Asteractis formosa **(Duch. and Mich.) Ver.**

Oulactis formosa D. and M., op. cit., p. 47, pl. VII, figs. 4, 5, 1860; Supl., p. 36 (130), 1866. Andres, op. cit., p. 291.

This is closely allied to the preceding species, but has smaller and less complex groups of lobulated actinobranchs on the collar and fewer tentacles. Guadaloupe.

Family Dendromelidæ McMurrich.

Lebrunia **Duch. and Mich., Corall. Ant., p. 48, 1860.**

Actinodactylus (*pars*) Duch. and Mich., op. cit., p. 44, 1860.
Stauractis (*pars*) Andres, op. cit., p. 255, 1884 (new name for last).
Taractea Andres, op. cit., p. 284, 1884 (for *L. Danæ*).
Lebrunea McMurrich, Actinaria Bahama Is., p. 33, 1889; Duerden, Actin. Jamaica, p. 456, 1898.

This remarkable genus is characterized by having a series of about six (sometimes 5 or 8) large, dichotomously branched fronds, or branchiæ (*actinobranchiæ*) exterior to the tentacles. The species examined by me has, on these fronds, at the forks, many more or less spherical bodies having the structure of acrorhagi. There are numerous mesenteries, most of them perfect and bearing gonads. Sphincter muscle feebly developed or wanting.

The genus *Actinodactylus* Duch., 1850, was based on *A. Boscii* D., which may, perhaps, have been only a young *Lebrunia*. It was only 4 to 5 lines in diameter, with 15 small, simple tentacles, in a single circle, and with 5 elongated, pedicelled, trilobed fronds, the lobes with small subdivisions. It may, however, prove to be a distinct genus when larger examples can be studied.

The second species referred to it (1860), as *A. neglectus*, appears to be the young of *Lebrunia neglecta*, described in the same work. Although it was only 5 lines in diameter it had 30 tentacles and 5 dichotomously branched fronds.

***Lebrunia Danæ* (D. and M.) Verrill. Figure 15.**

Oulactis Danæ Duch. and Mich., op. cit., p. 47, pl. VII, fig. 10 (frond), 1860.
Rhodactis Danæ Duch. and Mich., Supl., p. 37, 1866.
Taractea Danæ Andres, op. cit., p. 284, 1884.
Lebrunea neglecta Duerden, Actin. Jamaica, p. 456, 1898.
? *Hoplophoria coralligens* Duerden, loc. cit. (*non* Wilson).*

Specimens of large size, up to 8 inches or more in diameter, were obtained by me at Bermuda, in 1898. These agree very well with the specimens described by Duerden from Jamaica, as *L. neglecta*, but not with those described by McMurrich under the same name. In having numerous rounded acrorhagi on the actinobranchs or fronds (fig. 15) my species agrees with the *Oulactis Danæ* D. and M., from St. Thomas, which is evidently a *Lebrunia*, and there is no reason to doubt its identity with the Bermuda species.

My larger examples were usually dark green in life, with the tentacles somewhat paler green and flecked more or less with white; disk olive-green with whitish radial spots; fronds bluish green with the tips and rounded bodies light blue. It lives with the body concealed in holes or crevices of the reef-rock, at and below low-water mark. The tentacles are long.

***Lebrunia neglecta* Duch. and Mich.**

Lebrunia neglecta Duch. and Mich., op. cit., p. 48, pl. VII, fig. 8, 1860 (young).
Andres, op. cit., p. 362 (*non* Duerden).
? *Actinodactylus neglectus* Duch. and Mich., op. cit., p. 44, 1860 (very young).
? *Stauractis incerta* Andres, op. cit., p. 255, 1884 (new name for last).
Lebrunea neglecta McMurrich, Actin. Bahama Is., p. 33, pl. I, fig. 7 (general), pl. III, figs. 11–14 (anatomy).

This species was originally based on a small specimen (about one-half an inch high), but it had relatively large, much dichotomously divided fronds, according to the figure. McMurrich has given a detailed description of a species that appears to be the same, though much larger in size. His figures represent the 6 fronds as dichotomous, but with few divisions, though in

* The *Hoplophoria coralligens* Wilson, was described from a single, very small specimen (diameter about 2^{mm}), having 48 unequal tentacles and 4 simple, elongated, marginal fronds. Duerden identified with it a small form of *Lebrunia*, having dichotomous fronds and agreeing nearly in color, etc., with *L. Danæ*. The identity of his specimens with the true *Hoplophoria* seems to me very doubtful. This generic name is unfortunate for its variants, *Hoplophorus* and *Hopliphorus*, had been used previously for five distinct genera. It evidently cannot be the young of either nominal species of *Actinodactylus*, for although much smaller, it has more tentacles. It is most likely to be the young of *Diplactis Bermudensis* McMur., or some similar species.

his description it is stated that they "dichotomize many times until a dendritic structure is produced." The rounded bodies are not figured nor described by him, nor by D. and M. as occurring on the fronds. In this respect the fronds are very different from those of the Bermuda species studied by me. I am, therefore, disposed to believe that there are two large West Indian species.

Subfamily ALICIINÆ = Family ALICIADÆ Duerden.

Duerden, Ann. and Mag. Nat Hist., 6, xv, p. 213, 1895; Haddon and Duerden, Sci. Trans. Roy. Dublin Soc., vi, p. 153, 1896.

This family was established to include certain tuberculated genera, such as *Alicia* (= *Cladactis* Panc.), *Cystiactis*, etc.

It is characterized by a thin wall; feeble, diffused sphincter muscle; hollow tubercles, usually compound, on the column; 12, 24, or more pairs of perfect mesenteries; no acontia.

The wall-tubercles are thin and doubtless serve as branchiæ; they are not adhesive suckers.

The group is practically equivalent to tuberculated *Actinidæ*, and might well form a subfamily of that family.

Eucladactis Ver., new name. Type, *E. grandis* V.

Cladactis Ver., Trans. Conn. Acad. Sci., i, p. 472, 1869 (*non* Panceri, 1868).

By a mere coincidence the name *Cladactis* was given by M. Panceri and myself to two distinct genera, at nearly the same time. The former appears to be the same as *Alicia* Johns. which preceded it. No other name seems to have been given, as yet, to my *Cladactis*. The latter is characterized by very numerous tentacles, which are scarcely retractile; column thickly covered with hollow clavate and lobulated tubercles, the upper ones larger and more lobed than the rest; margin with a deep fosse; sphincter muscle very feeble and diffuse, or almost lacking; 36, 48, or more pairs of perfect and many imperfect mesenteries, having feeble muscles extending along most of their breadth; gonads numerous, borne on most of the mesenteries, both perfect and imperfect; a distal septal foramen; mouth large, with two large equal siphonoglyphs; lips with very numerous lateral furrows.

Eucladactis grandis Ver. Figures 13, 14.

Cladactis grandis Ver., Trans. Conn. Acad. Sci., i, p. 473, 1867. Andres, op. cit., p. 226, 1884.

The larger specimens of this species are over 2 inches in diameter and height, as preserved in alcohol. The tentacles

are partially contracted in length and sulcated, but are rarely concealed, even in the young, by the infolding of the margin of the disk; generally they are fully exposed and the margin is but little contracted or not at all, owing to the feeble development of the circular muscles. There are about 480 tentacles in the larger specimens; they form five or six crowded rows, the inner ones standing about half way between the center and the margin of the disk; the inner ones are larger and somewhat swollen at the bases but are not much longer than the outer ones; all are sulcated by contraction. The lips have about 48 to 60 furrows on each side. The mesenteries are hexamerous and, like the tentacles, vary in number according to the age. A medium-sized specimen had about 120 pairs, of which about 48 were perfect, but the arrangement is more or less irregular, for one, two, or even three imperfect pairs may intervene between the various perfect pairs. The larger specimens have about 60 pairs perfect and about 180 imperfect. Nearly all bear gonads. The larger upper actinobranchs (fig. 14 *a*, *c*), next the smooth fosse, are elongated, more or less clavate, the distal portion divided into four to six irregular rounded or obtuse lobules; those lower down become shorter and less lobulated, but nearly all are clavate or capitate, to the base, and most of them, in large specimens, are divided into two, three, or more lobules. They are thickly crowded over the whole surface, and in alcoholic specimens appear to be united together in horizontal series by thin folds of the wall (fig. 14 *b*).

Panama; Paita, Peru; San Salvador.

Explanation of figures.

Fig. 7. *Haloclava producta* (St.). Type, natural size.

Fig. 8. *Anthopleura Dowii* V. Side view of a tentacle, actinobranch, and two upper verrucæ. Enlarged.

Fig. 9. A similar view of the same organs of *Anthopleura Stimpsoni* V., from the type, enlarged.

Fig. 10. *Asteractis Bradleyi* V. Type, about natural size.

Fig. 11. The same, side view of tentacles and actinobranchs.

Fig. 12. The same, view of a portion of the disk, tentacles, pseudofronds, enlarged.

Fig. 13. *Eucladactis grandis* Ver. Type, ½ natural size.

Fig. 14. The same; *a*, one tentacle and a single vertical row of actinobranchs; *b*, a group of actinobranchs or papillæ from the middle of the column; *c*, various forms of marginal actinobranchs.

Fig. 15. *Lebrunia Danæ*, one of the actinobranchs with acrorhagi, ½ natural size.

Figs. 8 to 15 are by A. H. Verrill. Fig. 7 is by Wm. Stimpson.

Erratum—In part I, p. 494, line 17, for W. E. Coe, read W. R. Coe.

ART. VII.—*Mineralogical Notes: Analyses of Tysonite, Bastnäsite, Prosopite, Jeffersonite, Covellite, etc.;* by W. F. HILLEBRAND.

IN the following pages are given the results of several analyses of minerals made in the laboratory of the U. S. Geological Survey during the past few years. In the cases of tysonite and bastnäsite the results show that the formulas attributed to them are correct, which in the absence of fluorine determinations could not hitherto be affirmed. In the other cases the analyses are interesting only as affording additional data regarding rare minerals from new localities.

Tysonite and Bastnäsite.

These minerals formed a single fine specimen half as large as the fist, without crystal faces, from Cheyenne Mountain, near Pike's Peak, Colorado. The bastnäsite covered one side of the tysonite to the depth of an inch. The line of demarcation between the two minerals was sharp, but examination of their sections by Mr. H. W. Turner showed the tysonite to be permeated by stringers of bastnäsite along numerous cracks and that occasional grains of the latter were imbedded in the tysonite, which accounts for the CO_2 shown in the tysonite analysis. Attached to the tysonite at portions of its surface were other white and brownish alteration products derived from it, as shown by qualitative tests. The tysonite was evidently the remnant of a single large crystal, since, according to Mr. Turner, all parts had the same optical orientation. Mr. Turner further found the optical properties of both minerals, so far as determinable, to agree with those given in Dana's Mineralogy, and the index of refraction of the bastnäsite to be greater than that of the tysonite. He likewise noted in both minerals minute colored inclusions, indeterminable and very trifling in amount, and also in the tysonite "numerous minute angular cavities in which there is a liquid, often with gas bubble. Minute, clear, cuboidal crystals, apparently isometric, were also noted in some of these cavities."

The composition of the minerals was found to be as given by Allen and Comstock, with the exception that the ratios of cerium oxide to the oxides of the lanthanum group are not quite the same. The formulas are not thereby affected.

Cerium was separated from the lanthanum group oxides by two precipitations by potassium hydroxide followed by long introduction of chlorine. After recovery of the earths remaining in solution, they were again subjected to this treatment to be certain of having all the cerium. In one case a small portion was thus recovered. The cerium was most carefully examined for thorium and traces of what appeared to be thoria

were found. The other earths were wholly precipitable by potassium sulphate with exception of traces of what may be oxides of the yttrium group. Approximate molecular weight determinations of the combined oxides of these two groups were made, and they show an appreciable difference, which may, however, be due to the uncertainty of the method. It may be mentioned that on ignition of the sulphates of these earths they acted like the old didymium in that they lost exactly two-thirds of their SO_3 on ignition over the full flame of the Bunsen burner, a fact which would seem to exclude the presence of lanthanum. Their solutions were pink and gave pronounced absorption spectra. The ignited oxides freed from cerium were a dull dirty brown, which became nearly white on blasting and acquired a distinct bluish cast on ignition in hydrogen. No appreciable reduction in weight followed heating in hydrogen. The material saved is at the disposal of any one desiring to examine these earths spectroscopically.

Owing to the great difficulty in effecting complete decomposition of the minerals by sulphuric acid at a single treatment, the fluorine was obtained in condition for estimation by fusing with potassium carbonate after mixing with silica in the proportion of 0·6 gram mineral to 1 gram silica.

Fragments of tysonite when held in the blast gave a distinct crimson flame showing the lithium red line, but an alkali determination failed to reveal more than a trace of this element.

Of the bastnäsite very little pure material could be separated, and it was therefore impossible to place with certainty all the loss shown by the analysis, but a portion of it is to be charged to the oxides of the lanthanum group because of an accident.

Sp. grav. of the bastnäsite 5·12 at 27° C. and of the tysonite 6·10 at 28° C., which becomes 6·14 when corrected for 2·65 per cent of bastnäsite.

Analysis of Tysonite.

Ce_2O_3	42·89*
La group	39·31†
F	28·71‡
CO_2	·53
CaO	·18
Fe_2O_3	·11
Na_2O§	·30 (approx.)
	112·03
Less O for F,	12·08
	99·95

* 13 per cent ThO_2?
† At. w. 139·7; includes ·21 per cent soluble in K_2SO_4.
‡ Mean of 28·86 and 28·56.
§ With traces of K and Li.

Analysis of Bastnäsite.

Ce_2O_3	37·71*
La group	36·29† (low)
F	7·83
CO_2	20·03‡
Fe_2O_3	·22
Na_2O§	·18
H_2O	·08
	102·34
Less O for F	3·30
	99·04

* Mean of 37·73 and 37·69; includes ·10 per cent ThO_2?
† At. w. 141; includes ·09 per cent soluble in K_2SO_4.
‡ Mean of 19·94 and 20·11.
§ With traces of K and Li.

Neglecting the three last constituents in each case, the ratios become for

Bastnäsite.... $R : F, CO_3 = 1 : 2{\cdot}94$
Tysonite..... $R : F, CO_3 = 1 : 3{\cdot}05$

which ratio for tysonite is not changed by allowing for admixed bastnäsite.

The above direct fluorine determinations fully establish the hitherto assumed formulas, $R'''F_3'$ for tysonite and $R'''(F,'CO_3'')$ for bastnäsite.

Prosopite.

Over two years ago Mr. Geo. F. Kunz sent for examination a beautiful pale green mineral from Utah, supposed to be identical with the green variscite called by him utahlite in Mineral Resources of the U. S., 1894, p. 602. Under a recent date Mr. Kunz writes that Mr. T. H. Beck of Provo found the mineral "in 1895, in the Dugway mining district, Torvel Co. It was found in a low range of hills about five miles long, surrounded by a desert on an arid region occurring as flat rock, associated with fluorite, native silver and slate, and trachytic rock (?), containing decomposed pyrite in which there was present a little free gold."

Unexpectedly this was found to be the hydrous aluminum-calcium fluoride prosopite, mixed with some quartz and probably fluorite and colored by a small amount of some copper salt. A new and interesting occurrence for this very rare mineral is thus afforded.

The material as prepared for analysis after separation by a heavy solution proved to be still far from pure; quartz grains in amount from one to two per cent were left undissolved after complete conversion of the fluorides into sulphates and presumably considerably more had been removed by the escaping fluorine. The total amount of quartz was not determined and the material at hand did not suffice for attempts at more complete purification, so that the conclusions drawn from the analysis, while extremely probable, are not to be taken as altogether proven.

The sp. gr. of the mineral as analyzed was 2·87 at 21° C. and the hardness about 4·5, both agreeing with the constants for prosopite. Furthermore, but little of the water (1·25 per cent) was expelled by several hours heating at 280° C. Analysis gave:

Al	20·08
Ca	17·55
Mg	trace
K	·12
Na	·32
Cu	·17
F	28·00
H_2O	14·24
Quartz and oxygen	19·52
	100·00

Neglecting copper, alkalies, and the oxygen calculated for their oxides, and assuming the water to exist entirely as hydroxyl, the following not very satisfactory atomic ratios result:

Al	·7407	2
Ca	·4380	1·18
F	1·4690	8·23
Hydroxyl	1·5808	

which become

Al	·7407	2
Ca	·3712	1
F	1·3354	7·87
Hydroxyl	1·5808	

if enough calcium and its equivalent in fluorine are subtracted to make the ratio Al : Ca exactly 2 : 1, on the not improbable assumption that fluorite is present as an admixture, an assumption that had to be made also for the Colorado prosopite in order to bring it into close agreement with Brandl's formula.

There is now a deficiency in the acidic radicals. The figures for Al, Ca, and H_2O are undoubtedly very nearly correct while the fluorine may well be half a per cent low, having been determined by the Berzelian method, owing to the difficulty of securing complete decomposition of the fine powder by a single treatment with sulphuric acid. Let it be permitted to balance the basic and acidic radicals by raising the fluorine, and to figure the ideal percentages on this basis. These become of interest when compared with the corresponding figures for prosopite from Altenberg and Pike's Peak as given below:

	Altenberg.	Pike's Peak.	Utah.
Al	23·37	22·02	22·74
Ca	16·19	17·28	16·85
F	35·01	33·18	29·95
H_2O	12·41	13·46	16·12
O	12·58	13·41	14·34
			100·00

If the assumptions made in the foregoing are justified, the Utah mineral is prosopite, and further evidence is afforded of the correctness of the view established by Penfield that fluorine and hydroxyl can mutually replace one another in many mineral species, for their relative proportions differ materially in the prosopite from the three known localities. The correctness of the formula as applied to the Colorado and Utah prosopite is, however, predicated, as said, on the unproven assumption that the material analyzed contains some admixed fluorite.

Jeffersonite.

Two brown substances associated with franklinite and other zinc minerals from Franklin Furnace, N. J., so alike in appearance as to have been taken for the same mineral species, were received from Mr. Geo. L. English. One was a little duller than the other and proved to be a mixture of several minerals according to Mr. F. L. Ransome of the Geological Survey, largely pseudomorphic after some micaceous mineral. From Prof. Clarke's calculations, based on the following analysis, it might be a mixture of a calcium-aluminum garnet, troostite, and limonite. SiO_2 32·09, Al_2O_3 11·12, Fe_2O_3 5·16, MnO 15·85, ZnO 16·89, CaO 15·65, H_2O 2·15, MgO and alk 1·12; total 100·00.

The other was of a richer and deeper brown and showed such a pronounced cleavage or parting in one direction as to produce a lamellar structure. The luster was brilliant on these cleavage surfaces. Other directions of cleavage were apparent. The hardness was about 5·5 and the density 3·39 at 21·5° C. Before the blowpipe a fragment fused with difficulty to a light colored blebby glass. Analysis gave:

SiO_2	51·70
Al_2O_3	·36
Fe_2O_3	·37
MnO	7·43
ZnO	3·31
CaO	23·68
MgO	12·57
Na_2O	·12
K_2O	trace
H_2O	·65
	100·19

TiO_2, FeO, P_2O_5 absent.

Neglecting the sesquioxides, alkalies and water, this leads to the ratio $SiO_2 : RO = 1 : 1·02$, and the formula is that of a metasilicate $R''SiO_3$. According to Mr. English the material

submitted by him had been pronounced by Prof. Penfield on the basis of qualitative tests to be jeffersonite, a manganese-zinc pyroxene, a statement supported by the analysis above given, although neither the color of the mineral nor its quantitative composition agree with the hitherto published data. In Dana's Mineralogy the color is given as "greenish black, on the exposed surface chocolate brown," the density as 3·36 on p. 358, but 3·63 on p. 360. The discoverers of the species, Keating and Vanuxem, give 3·50–3·55 for the density and 4·5 for the hardness. The present mineral presents all the evidences of being fresh and unaltered, yet it is brown throughout, and its analysis furnishes figures widely at variance with those of Herrmann and of Pisani, but giving a better metasilicate ratio than either of their analyses. Notwithstanding these discrepancies, there is no reason for ascribing to the mineral a new sub species name. The analysis is chiefly valuable as showing a wide range of composition for the mineral.

Covellite, Enargite, Stalactite.

The only important occurrence of covellite in this country is at Butte, Montana, where it occurs in splendid indigo-blue masses. Specimens from the East Greyrock mine, collected by Mr. Geo. W. Tower of the Geological Survey, gave almost the theoretical composition as shown below. Sp. gr. at 26° C. 4·76, uncorrected for impurities.

An analysis of enargite collected by Mr. Tower in the Rarus mine, and of a beautiful sky-blue stalactite from the Anaconda mine, both at Butte, are likewise given.

Covellite.		Enargite.		Stalactite.	
Cu	66·06	Cu	48·67	CuO	9·32
S	33·87	Fe	·33	FeO	·18
Fe	·14 = ·30 FeS_2	Zn	·10	MgO	·08
Insol.	·11	As	17·91	Al_2O_3	10·67
	100·18	Sb	1·76	SO_3	35·05
Ratio Cu : S as 1 : 1·01		S	31·44	P_2O_5	1·13
		Insol.	·11	As_2O_5	·07
			100·32	H_2O	43·44
				Insol.	·06
					100·00

The stalactite was of some size, and was most readily soluble in cold water, the solution giving a strong acid reaction. The calculated ratio is strongly acid, showing either a mixture of highly acid salts or of normal salts with free acids.

Fibrous sulphate.

Mr. W. H. Weed collected in the St. Paul mine, near Whitehall, Montana, a magnificent specimen of a compact soluble fibrous sulphate, supposed to be melanterite. It seemed to be a filling between fragments of broken rock. Outwardly it was white from dehydration, but at some depth the unaltered green mineral was to be found. This had the following composition:

Al_2O_3	4·34
FeO	9·04
NiO	·03
MnO	2·62
ZnO	1·06
CuO	·05
CaO	·09
MgO	3·07
Na_2O	·07 ?
SO_3	29·88
Cl, CO_2	none
H_2O	48·84
Insol.	·16
	99·25

Of the water 10 per cent escaped in 24 hours over sulphuric acid and only ·4 per cent more in another like period, but a total of 14·4 per cent after 10 days uninterrupted exposure. The water thus lost is very slightly reabsorbed on exposure to air.

From calculations by Prof. F. W. Clarke the substance may be regarded as a mixture of alunogen or the halotrichite group with salts of the melanterite group, the empirical formula being nearly

$$(Fe, Mn)_4(Zn, Mg)_3Al_2(SO_4)_9 . 65H_2O.$$

The outer white zone of the specimen contained only 39·62 per cent of water.

Laboratory of the U. S. Geological Survey, July.

Art. VIII.—*What is the Loess?* by F. W. Sardeson.

There is wide difference of opinion regarding the origin of the American loess. Is it an aqueous or an æolian deposit? Many believe it to be partly aqueous, partly æolian, and thereby raise the very important question of how to distinguish the one kind of loess from the other. To those who view the loess as æolian, this discrimination is easy, for the loess is all æolian except locally where distinct sedimentary characters appear. The loess is interpreted by them as wind-carried dust, deposited on a land surface interrupted by streams and ponds.

The loess viewed as a sediment is also easily distinguishable from other sediments, but requires then the very difficult explanation of how a little altered glacial sediment could be so peculiar,—in fact like dust deposit. Negative evidence to this theory is found in a region like Minnesota, where there are thousands of existing and extinct lakes of glacial origin, in not one of which is loess known to have deposited,—not even in Lake Agassiz. They have in them gravels, sand and silt, and around them are beaches. No small nor shallow lake could have spread over the extremes of altitude on which the loess lies, and a necessarily huge body of water must have left some beaches and coarse sediments besides silt or loess. It was not a lake that deposited the loess. The loess could also scarcely be all a glacial sheet flood deposit. For example, the Iowan loess lies beyond the Iowan drift sheet as it were its continuation. Either the loess is the older and hence remains intact only beyond the Iowan glacier's domain, or else the loess is contemporaneous and deposited by agency of the same glacier's waters. The latter is the sedimentary theory. But the theory does not explain why the glacial waters ceased depositing loess when the glacial retreat began. Iowan loess does not cover the Iowan drift,* and this fact the æolian theory alone can explain. Partial or entire recognition of the æolian origin is necessary.

Partial recognition does not, however, remove all inconsistencies, because "no means of discriminating between the two kinds of loess are yet known to be formulated,"† as the advocates of the mixed hypothesis‡ say. Prof. T. C. Chamberlin teaches this double origin of the loess, and his view, as understood by the writer, is that the glacial waters flooded

* Prof. S. Calvin discredits the reported slight occurrence of this loess on the Iowan drift. Iowa Geol. Sur., vol. viii, p. 174; see also p. 339.

† C. R. Keyes, this Journal, vol. vi, p. 229.

‡ T. C. Chamberlin, Jour. Geol., vol. v, p. 795.

sediments upon the land, and these were in part modified by æolian agent into "bluff loess."

In theory, the Chamberlin view may be essentially correct. The loess particles came from the drift, and very probably from washed drift largely. If the theory be applied, it should bring into recognition the following kinds and relations of deposits: the unassorted glacial deposit, or till; this, when assorted by agency of water, becomes stratified gravel, sand and silt; the two latter may be made by æolian agent into dune sand and "bluff" loess; and they, after erosion, may become again respectively stratified sand and silt; under the action of humic acids the silt of both kinds may be reduced to a loam in which there is no lime; and likewise the "bluff" loess may be reduced entirely, or to a degree, to "loess" loam. The till is easily recognized, as are also the stratified products, the gravels and sands. Dune sand lacks the assorted and stratified structure, and is easily distinguishable from the sedimentary patches associated with or in it. It seems strange, therefore, that silt and æolian deposit,—that is mud and dust,—should not be distinguishable.

Indeed, it is not difficult to discriminate between glacial silt and loess, and I believe that they are rarely if ever confused by geologists. The difficulty lies in the discrimination of theoretical sedimentary loess and æolian loess. There *are* two kinds of loess in the Mississippi basin, and they are distinguishable at a glance, but as said, they have not been proved separable on the basis of sedimentary and æolian origin. The two kinds are very intimately associated. They are respectively the characteristic calcareous, porous, "bluff" loess and the oxidized portion of the same, which may be called loess loam, residuary loess, or ferretto. Difference in color, or the application of hydrochloric acid, serves as a ready test of them.* Chamberlin and Salisbury, in their monograph, recognized the loess loam of the "Driftless Area" as residuary clay although they failed to connect it with the loess, as I have once before indicated,† and in fact Chamberlin has practically admitted the emendation by criticising other parts only of my paper.‡ The loess loam being due to oxidation by humic acids, its depth is determined by the vegetation upon its surface and by the time that this agent has acted, provided that the loess be not too shallow and surface erosion does not equal or exceed the rate of oxidation. On the Missouri and Mississippi River bluffs, the loess was originally deepest; it is also little covered with vegetation and highly exposed to erosion. On the higher

*This distinction is not new, for example see Geologischer Fuchrer d. Umgebung v. Freiburg, p. 78, Steinmann u. Graeff, 1890.

† Am. Geol., vol. xx, No. 6. ‡ Jour. Geol., vol. v, No. 6.

but more level land farther from the great rivers, the loess was thinner and was also more oxidized. Often it is all oxidized.

From my own observations compared with published descriptions, I feel safe in saying that, as a rule, the loess loam is what has been called sedimentary loess. If it *were* such, why is it not calcareous as are the known glacial silts? And if the "bluff" loess is derived from it, why is the former calcareous, since the latter is not? There is no explanation.

The above criticism applies to the loess as a rock type, but when the Loess formation is considered another distinction should be admitted, namely that there are two distinct loess formations, as H. F. Bain describes in northwestern Iowa,* which are comparable to the older and younger loess of the Rhine Valley. Each may bear loam.

The loess as a formation bears loam both upon and within. Upon the loess, the loam represents the portion which has been oxidized since the loess formation was deposited, while in the same it indicates patches of vegetation that were contemporaneous with the deposition. The loess loam, in combination with land and fresh water shells, forms the very strong argument in favor of the purely æolian origin of the loess. The æolian hypothesis is the one which permits the several parts of the loess to be both readily interpreted and easily recognized in the field, and it has therefore a distinct advantage over the semi-æolian hypothesis. It is further competent to explain without inconsistency the dune sands on the river bluffs and their graduation into the loess; wind polished pebbles lying between till and loess are recognized; two kinds of stratified silts existing with the loess or graduating into it are identified as respectively glacial silt from which the loess seems to have been largely derived, and modified or washed loess. Banded structure in the loess,† which is not true stratification, indicates the line of a moist zone where vegetation thrived and oxidized the loess. Dry runs and very probably rodent burrows and mounds can be easily recognized; and the occurrence of land and fresh water shells is not anomalous. Finally, when it is observed that much loess accumulated before one glacial period or ice advance and little before another, the same is consistently attributed to climatic conditions, to which kind of cause the glaciers themselves are referred.

University of Minnesota, Minneapolis.

* Iowa Geol. Sur., vol. viii, p. 240.

† See for example, fig. 32, p. 235, vol. vii, Iowa Geol. Sur.

Art. IX.—*Absorption of Gases in a High Vacuum;* by C. C. Hutchins.

The term "absorption" is here used to cover the general phenomenon of the disappearance of the residual gas in a high vacuum under the electric discharge, whatever may be the cause of the disappearance.

It is well known to all users of X-ray apparatus that under the discharge from an induction coil the tubes rapidly rise in vacuum, and the current, after a longer or shorter time, ceases to pass, and the usefulness of the tube is at an end. This rise in vacuum constitutes the most serious defect in such tubes and is a source of constant annoyance.

It is probably safe to reject the theory that the electromotive force drives the molecules of the residual gas through the walls of the glass. It is possible to have an opening into a highly exhausted tube without the entrance of air.

This laboratory has for twenty years possessed a Crookes radiometer that has during all that time been cracked entirely around near the top of the bulb, but which, notwithstanding, continues to function perfectly. We also had for several months an X-ray tube similarly cracked. By constant use this tube became so high in vacuum that it was punctured by a spark; air entered and the cracked end fell away of its own weight.

The disappearance of the gas is therefore probably due to mechanical and chemical combination with the metallic electrodes of the tube, and it should be possible to find some gas or vapor whose rate of absorption would be less in rate or extent than that which takes place in the ordinary tubes.

The first step in the inquiry is to learn what the ordinary high-vacuum tube contains.

If a Plücker tube, made from carefully cleaned glass, be very highly exhausted and then the current from an induction coil turned into it, the vacuum falls at once, air and water being driven from the walls of the tube. If now by heating the tube, continuing the current and working the pump, the vacuum be again raised to the point at which the fluorescence of the glass appears, the spectrum of the tube will be found to consist of the red and blue lines of hydrogen (C and F), and three or four lines of oxygen; that is, the tube contains only water. The tenacity with which glass retains water upon its surface is well known; and it is necessary to heat the glass nearly to its softening point before the last of the water comes away. When the vacuum in a tube is so high that the current will not pass, heating the tube will dislodge a little water and the current will pass until the water has again condensed upon the cooling of the tube.

As the following experiments had for their object the production of a permanent state of vacuum under the electric discharge, they were limited to such gases as could be produced readily in the tubes themselves, and whose use seemed to hold out promise of success.

A number of Plücker tubes were made, as nearly alike as possible, and each provided with a small communicating tube containing some chemical that would yield the desired gas by the application of heat. The chemicals were prepared as pure as possible, and dried at a hundred degrees for twenty-four hours. The dried-out tubes, containing the chemicals, were then attached to the mercury pump and exhausted; heated very hot and pumped to remove all water vapor. The tube containing the chemical was then heated, gas driven off into the tube and the exhaustion repeated.

In nearly every case it was found impossible to entirely get rid of water vapor, even by repeatedly washing out with the gas. The tubes were sealed at such a degree of exhaustion as would allow the subsequent rise in vacuum to be well marked,—when the green fluorescence of the glass appeared at the cathode, and the sparking distance across the terminals of the coil and in parallel with the tube was 2^{mm}. After the tube was sealed, it was placed before a spectroscope, and the current from the coil passed until the spectroscope showed the entire absorption of the gas, or until the vacuum became too high for the current to pass readily. A fairly good idea of the relative rates of absorption of the various gases may be obtained from the time required for the absorption to take place.

Tube containing zinc cyanide. — This substance yields cyanogen when heated. The tube was washed out with the gas as above described and sealed. The vacuum began to rise at once as soon as the current was turned on. In five minutes the whole tube became fluorescent, and in seven minutes the cyanogen was entirely absorbed, the spectrum being now that of the trace of water vapor from which the zinc cyanide could not be freed. It is difficult to see why a gas which if decomposed by the discharge would remain as the chemically inert nitrogen, should disappear at such an extraordinary rate. To test the matter further another tube was made in such form that when the vacuum became higher than a certain value, a portion of the current was shunted through a platinum wire surrounded by zinc cyanide, and so the vacuum was automatically maintained nearly constant. This tube was worked for four hours, and the yield and absorption of the gas went on for the whole time at a nearly constant rate.

Tube containing lead ferrocyanide, yielding nitrogen when heated, also gave considerable water vapor. Sealed at a slightly lower vacuum than the first, yet the nitrogen all

vanished in ten minutes, water alone remaining. As it was possible in these two cases that the gases had undergone reabsorption upon the cooling of the substances from which they had been expelled, a fresh portion of the gases was driven off and the tubes allowed to stand twenty-hours. No change could be observed in them.

Tube containing iodine.—The iodine was shut off from the main tube by a stopcock, fearing its vapor tension at ordinary temperatures would be too great to admit of obtaining a sufficiently high vacuum. The tube was exhausted, the stopcock opened for a moment to fill the tube with iodine vapor, and the exhaustion repeated. After sealing, the iodine disappeared under the action of the current in less than a minute. The tube was filled with iodine vapor again by opening the stopcock and warming the tube. Upon again starting the current the platinum mirror upon the glass at the cathode was seen to be attacked and converted into a dark bronze-colored substance and the iodine again disappeared.

Tube containing oxide of mercury, yielding oxygen when heated, but no water vapor. Tube pumped and heated very thoroughly, and when sealed showed the spectrum of oxygen and the red hydrogen line faintly. The vacuum rose slowly; after fifteen minutes the hydrogen line disappeared; at the end of an hour the vacuum had become quite high, the spark in parallel with the tube being two inches, but the current still passing easily. The spectrum of the tube then consisted of three lines of oxygen.

Experiments were also made with carbon dioxide and some other gases, the details of which need not be given here, inasmuch as it was found that oxygen was absorbed far more slowly than any other substance tried. Mercury oxide is also eminently adapted to maintaining a condition of constant vacuum. It yields oxygen only at a high temperature, and the flow of gas ceases immediately upon withdrawal of the source of heat.

To construct an X-ray tube in which the vacuum may be maintained at the most efficient point, it is only necessary to attach near the anode terminal a short tube having a sealed-in platinum wire packed around with oxide of mercury. A plug of asbestos may be used to hold the substance in place. When by use the vacuum becomes too high, a portion of the current is shunted from the cathode through the oxide of mercury for a brief time; a little gas is dislodged and the tube becomes as new. The shunt may be left permanently in place with a longer or shorter spark-gap at the mercury terminal. The action will then be automatic, and vacuum remain indefinitely at any desired point.

Searles Physical Laboratory,
Bowdoin College, November, 1898.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *On the Extraction of Nickel by the Mond Process.*—A paper by Roberts-Austen has recently appeared giving an account of the application of the volatile nickel-carbonyl, discovered by Mond, to the extraction of nickel from its ores. Mond's discovery was that metallic nickel forms a volatile compound with carbon monoxide, which he called nickel-carbonyl, which boils at 150° and from which the nickel may again be regenerated by heating to 180°. Iron, while not as active, acts similarly. The suggestion was an obvious one, that by means of these volatile compounds, these metals might be separated from cobalt, copper and the others with which they are associated in their ores. An experimental plant was erected in 1892 near Birmingham. The material used was Bessemerized matte, which after roasting contained 35 per cent nickel, 42 per cent copper and about 2 per cent of iron. By treatment with sulphuric acid, about two-fifths of the copper was removed, the residue containing 51 per cent of nickel. The remaining copper was reduced to the metallic state by means of water gas at 300°. The ore was then treated in a volatilizing tower with carbon monoxide, the temperature being kept below 100°. The volatile nickel carbonyl passed to a decomposer—a horizontal retort heated to 180°—where the nickel was released in the metallic form and the carbon monoxide returned to the volatilizer to be again used. The unused metallic residue was returned to the roasting furnace. The nickel produced was 99·8 per cent pure. Up to the time Professor Roberts-Austen visited the plant, about 80 tons of nickel had been thus prepared, with quite satisfactory results.—*Nature*, lix, 63, November, 1898.

G. F. B.

2. *On Ætherion.**—A note on ætherion has been published by Crookes, giving some of his old researches made from 1873 to 1881, tending to show that the new gas may be nothing more than aqueous vapor. Early in his investigations he noticed that a little aqueous vapor thrown into the vacuum [of a radiometer], converted into attraction the repulsion due to radiation. In 1880, he observed that aqueous vapor was found to retard the force of repulsion to a great extent and carbonic acid acted in a similar way, though less in degree. "The presence of even a trace of aqueous vapor was found to have a strong action in diminishing the sensitiveness of the radiometer and other instruments," he says. As to the absorption of ætherion by glass and its evolution again on heating, the author gives an experiment made in 1879 showing that air-dry glass condenses on its surface a considerable quantity of water and carbonic acid which does not come off

* This Journal, IV, vi, 431, November, 1898.

until heat is applied. As to its conductivity for heat, experiments are described which show that at high vacua water gas is a better conductor than either air or hydrogen at similar pressures. "It has been found," he says, "that as water gas is rarefied, its heat conductivity diminishes in a greater ratio than that of hydrogen." "At these high vacua water gas gains so rapidly on hydrogen that I am prepared to believe that at Mr. Brush's low pressure of 0·38 millionth, the ratio may even be as great as that he ascribes to etherion." "On the evidence at present available," he concludes, "I consider it more probable that ætherion is water vapor than that it is a new elementary gas."—*Chemical News*, lxxviii, 221, November, 1898. G. F. B.

3. *On the Preparation of Graphitic Acid.*—An easy method of preparing graphitic acid has been described by STAUDENMAIER. A mixture is first made of 100^{cc} of concentrated nitric acid (sp. gr. 1·4) and 300^{cc} of ordinary strong sulphuric acid. To this are added 50 grams of pulverized Ceylon graphite, and then 100 grams of potassium chlorate, in small portions at a time; the whole being frequently stirred. After the mixture has stood for several hours, it is poured into water, and the solid is washed, dried and ignited in a large dish of metal until it has intumesced. Then it is again stirred with water, and the portion that floats is collected for use in the subsequent operations. Of this prepared graphite, 25 grams are poured, with constant stirring, into a cold mixture of one liter of strong sulphuric acid and half a liter of strong nitric acid contained in a shallow dish, and then about 450 grams of potassium chlorate are added in successive portions. After the active evolution of gas diminishes, and a sample of the resulting green substance appears pure yellow on treating it with acid permanganate, the whole is poured into water, and the resulting solid is washed repeatedly by decantation. It is now placed in a dish and a solution is added to it consisting of seven grams of potassium permanganate dissolved in 120^{cc} of hot water; after cooling, a mixture of 15^{cc} of strong sulphuric acid with 75^{cc} of water is added, and the whole is heated on the water bath until the red color has disappeared. Hydrogen peroxide is added, the whole is allowed to stand at rest for some time with occasional stirring, and the graphitic acid is then washed first with dilute nitric acid and finally with alcohol and ether.—*Ber. Berl. Chem. Ges.*, xxxi, 1481–7, June, 1898. G. F. B.

4. *On Compounds of Lithium and Calcium with Ammonium.*—The fact has been observed by MOISSAN that when liquefied ammonia, contained in a tube cooled to —50°, is brought in contact with metallic calcium or lithium, solution takes place with the production of an intense blue liquid having a brown red reflection; this result being comparable to the similar phenomenon observed with potassium and sodium. These latter metallic ammoniums when thus produced, according to Joannis, have the formulas KNH_2 and $NaNH_2$, and they decompose at the ordinary temperature and pressure, evolving ammonia gas and regenerating

the alkali metal in brilliant crystals, as Seely long ago pointed out. As opinions differ as to whether these metallic ammoniums are molecular or atomic in constitution, the author has made experiments with potassium, sodium, lithium and calcium. Each metal was placed in a U-tube of glass, one leg of which was drawn out fine, while the other was recurved and connected with a source of ammonia gas, dried first over fused potassium hydrate and then over sodium. The four tubes were united successively so that the same current of ammonia gas traversed them all. By the use of a water bath, the temperature could be regulated, and the flow of gas increased or diminished by means of a tap. For low temperatures acetone was used in the bath, being cooled even as low as —75°, the solidifying point of ammonia, by adding to it fragments of solid carbon dioxide. The experiments were made under atmospheric pressure. It was found that lithium was attacked at +70° with liquefaction, calcium at +20° without liquefaction, potassium at —2° with liquefaction, and sodium at 20° with liquefaction. It is clear therefore that these four metals unite directly with ammonia gas, the temperatures obtained being the superior limits of the action and at the same time the decomposition-temperatures of the metallic ammoniums under the conditions. By preparing the metallic ammonium by the action of the liquefied gas, and then slowly raising the temperature, the inverse method was effected, the sodammonium dissociating at —20° and giving the metal and ammonia gas, and the potassammonium doing the same at —2°; while calcium-ammonium and lithium-ammonium were stable at the ordinary temperature and pressure. Moreover, ammonia gas solidified at —80°, does not attack either of the four metals, though action takes place as soon as liquefaction commences with evolution of heat. If the experiment is made slowly, the author states that amides of these metals are produced; while when it is rapid, the metallic ammonium may be readily produced at the ordinary pressure and the metal regenerated in crystals without the production of amides. Lithium placed in a U-tube at the temperature of the laboratory and subjected to a current of ammonia gas, takes a brownish-red tint and liquefies, producing a liquid of the same color. Heated rapidly to +70°, the excess of ammonia escapes, leaving a reddish-brown solid, which takes fire in contact with the air. If lithium be placed in liquefied ammonia, the tube being allowed to return slowly to the ordinary temperature, the dark blue liquid becomes thicker, reaching a sensibly constant composition after 24 hours. The composition then was found to be: NH_3 89·04, 87·00, 88·72, and 88·37 in four samples; the formula $(NH_3)_2Li$ requiring 87·93. The liquid may therefore be considered either as a saturated solution in ammonia gas or as a compound $NH_2Li.(NH_3)_2$. As to solid lithium-ammonium, its composition was determined (1) by weighing the ammonia fixed by the metal and (2) by preparing the compound and determining the ammonia in it. The lithium found in five experiments was 28·07, 28·40, 28·72 and 28·82 per cent.; the

ammonia being 71·93, 71·60, 71·28 and 71·18. Theory requires for NH_3Li, 29·16 of lithium and 70·83 of ammonia. It is much less soluble in liquid ammonia than the sodium compound. The metal calcium exposed at 15° to a current of ammonia gas takes a yellowish-brown tint, becomes heated and increases in volume. At a temperature between 15° and 20° only a solid compound is formed, which takes fire in contact with the air and which fixes liquid ammonia and becomes pasty, being then soluble in the liquid. Like lithium, it gradually decomposes at the ordinary temperature, yielding transparent crystals of amide $(NH_2)_2Ca$ and evolving hydrogen. On analysis calcium-ammonium gives numbers agreeing with the formula $(NH_3)_4Ca$.—*C. R.*, cxxvii, 685–692, November, 1898. G. F. B.

5. *On the Spectra of Iodine.*—The results of a measurement of the lines in the emission and absorption spectra of iodine from wave-length 3030·5 to wave-length 6191, expressed in Ångström units, have been given by KONEN. As is well known, either a line spectrum or a band spectrum can be obtained in a vacuum tube. The latter is composed of two different portions which may be designated as B_R and B_V; the former of these, B_R, is identical with the absorption band spectrum, while B_V is not. When the discharge is very intense, however, B_R disappears, while B_V increases in intensity; so that the author is inclined to the view that B_R is due to the ordinary iodine molecules, and B_V results from dissociation. In the line spectrum also, two series may be distinguished, but it is quite possible that in this case the second series may be produced by an impurity. Tables of the wave lengths are given in the paper.—*Ann. Phys. Chem.*, II, lxv, 257–286, 1898. G. F. B.

6. *A Manual of Chemical Analysis, Qualitative and Quantitative;* by G. S. NEWTH, Demonstrator in the Royal College of Science, London; 8vo, pp. xii, 462. New York, 1898 (Longmans, Green and Co.).—The author tells us in the preface to his book that he has "done his best to make it as little of a cram-book as possible, but has endeavored to teach *analytical chemistry* as well as analysis—that is, the theoretical as well as the practical side of the subject." Book I treats of Qualitative, Book II of Quantitative Analysis. The quantitative work is divided into gravimetric methods, including electrolysis, and volumetric methods, including gas analysis; special methods following these. The great convenience of having the leading facts well set forth in a work of moderate size, for the use of students taking short courses, is well exemplified in this manual. The portion on volumetric work seems especially good. G. F. B.

7. *Stratified Brush Discharges in Atmospheric Air.*—M. TOEPLER has described a species of stratification in brush discharges (Wied. Ann., lxiii, p. 109, 1897) and the present paper is a continuation of his studies in this direction. A sixty-plate Toepler-Holtz machine was employed, and it was found that the increase of potential-difference was closely proportional to the

increase of sparking distance; and that the potential difference at the electrode is nearly independent of the current strength if the discharge is of the nature of a brush. The G. Wiedemann-Hittorf law for Geissler tube discharges therefore holds also for brush discharges in free air.— *Wied. Ann.*, No. 12, 1898, 660–675.

The writer has substantiated the results of Toepler, as far as relates to the stratification, by the employment of an apparatus which can produce a difference of potential of three million volts. The stratification with this high voltage occurs in the neighborhood of the positive pole. J. T.

8. *The Spectrum of Lightning.*—Photographs of the light of a spark six feet in length, taken in the Jefferson Physical Laboratory, show atmospheric lines very strongly developed between E and H. No more lines were produced by a voltage of three million than can be brought out with a voltage of one hundred thousand. With the higher voltage, however, there is a complete absence of the metallic lines of the terminals. The photographs taken with the high voltage therefore must closely resemble the spectrum of lightning. J. T.

9. *Dispersion in the Electrical Spectrum.*—Observations on dielectric constants for periods between wave lengths 2^{cm} to 75^{cm} have hitherto been wanting. E. Marx has endeavored to supply this break in the subject and has applied to his results certain laws of dispersion. He speedily ascertained that in order to obtain very short electrical waves it is necessary to so interlock the primary and secondary circuits, or in other words the exciting and resonating circuits, in such a manner that only the fundamental vibrations of the primary circuit were in evidence. He employed Drude's method of measurement, which consists in nodes measureing the displacement of the electrical waves on wires, when a portion of these wires are surrounded by a dielectric. By means of an exciter of small dimensions he obtained electrical waves, 4^{cm}, 36^{cm}, and 58^{cm} in length. The positions of the nodes were ascertained by means of a Zehnder-Geissler tube. The index of refraction of electric waves, $3{\cdot}2^{cm}$ in length, for water was found to be

$$n^2 = 85{\cdot}0 \text{ (at } 17^\circ \text{ C.)}$$

For wave length 36^{cm}

$$n^2 = 82{\cdot}50 \text{ (at } 17^\circ \text{ C.)}$$

For wave length 53^{cm}

$$n^2 = 83{\cdot}73 \text{ (at } 17^\circ \text{ C.)}$$

The indices of refraction of ethyl-alcohol were similarly investigated. It was surmised that absorption bands of great extent in the ultra-red modify existing dispersion formulæ. A difference in concentration of the ethyl-alcohol solutions of 1 per cent can change the square of the electrical index of refraction 35 per cent. — *Wied. Ann.*, No. 11, 1898, pp. 411–434; ibid., No. 12, 1898, pp. 597–622. J. T.

10. *Traité Élémentaire de Méchanique Chimique fondée sur la Thermodynamique* par P. Duhem. Tome iii, Les Melanges

homogènes; les dissolutions, pp. 1–380. Paris, 1898 (Librairie Scientifique A. Hermann).—The third volume of the extensive work by M. Duhem, which was announced in volume iii, p. 419, of this Journal, has now been issued. It shows that the promises made at the outset are being thoroughly fulfilled, and that the work when completed will occupy a unique place in scientific literature.

The volume is divided into two parts; the first of these discusses homogeneous mixtures with respect to thermodynamic potential, osmotic pressure and the hypotheses of Van t'Hoff and d'Arrhenius; also chemical reactions in homogeneous systems. The second is devoted to solutions, discussing the solution of salts in general, the effect of vaporization of the solvent, with the formulas of Kirchhoff, the effect of freezing of the solvent, saline and gaseous hydrates, and double salts. This enumeration of the subjects of leading chapters will serve to show the scope of this part of M. Duhem's work, but only close study will make the reader familiar with the thoroughness of the discussion as a whole.

11. *Prismatic and Diffraction Spectra. Memoirs of Joseph von Fraunhofer.* Translated and edited by J. S. Ames.—The inauguration of the series of *Harper's Scientific Memoirs* was announced in the last number of this Journal (p. 504, Dec., 1898). The second volume has now been issued; it contains translations of Fraunhofer's classical papers (1817–1828). To these are added the note by Wollaston (1802) describing the method by which he obtained a pure solar spectrum and discovered the presence of fixed lines in it. This volume, like its predecessor, is edited by Prof. Ames.

II. Geology and Mineralogy.

1. *Maryland Geological Survey;* William B. Clark, State Geologist. Vol. i, pp. 1–539, plates i–xvii, 1897; Vol. ii, pp. 1–509, plates i–xlviii, figures 1–34, 1898.—Maryland was one of the first four states in the Union to institute an official geological survey, and, in the present series, is preparing the most elaborate and elegant geological reports that any state has so far produced. This second official survey of the state was organized by act of the General Assembly in March, 1896. The commission appointed Prof. Wm. B. Clark state geologist, and the two volumes are the work of the first and second years of the survey. The first volume, as the geologist says in the preface, "consists primarily of a summary of past and present knowledge concerning the physical features of Maryland, and embraces an account of the geology, physiography and natural resources of the state. The "Historical sketch," comprising Part ii, begins with the landing of Captain John Smith, in 1608, and narrates the work of the successive explorers and investigators who have developed the knowledge of the resources of the state. Part iv, on the Bibliography and Cartography, is compiled by Mr. E. B.

Matthews and includes a list of the works and maps published relating to the physiography, geology and mineral resources of the state, from 1526 to 1896, inclusive, and Part v is the first report by Mr. L. A. Baur on the magnetic work in Maryland, including the history and object of magnetic surveys in general.

Volume ii, in addition to the state geologist's administrative report on the operations of the survey during 1896, and during 1897, contains in Part ii an elaborate paper by Messrs. George P. Merrill and Edward B. Matthews, on the Building and Decorative Stones of Maryland, illustrated by beautiful colored pictures of some of the more important stones as polished, and micro-photographs of their structure. Part iii is an equally elaborate report on Cartography, to which Mr. Gannett, of the United States Geological Survey which is coöperating with the state survey, contributes a valuable paper on the aims and methods of cartography; and Mr. E. B. Matthews one on the maps and map-makers of Maryland.

The volumes are printed on excellent paper, and the illustrations are numerous and often of great beauty as works of art, and nothing seems to be spared to make the reports models of their kind.

H. S. W.

2. *The Lower Cretaceous Gryphæas of the Texas Region;* by R. T. Hill and T. W. Vaughan. Bull. No. 151, U. S. Geol. Survey; pp. 1–139, plates i–xxxv. Washington, D. C. 1898.—At last the *Gryphæa pitcheri* Morton, and the age of the Tucumcari beds, have been set at rest. Mr. R. T. Hill has succeeded not only in solving, but in clearly demonstrating his solution of the perplexing problems regarding the Lower Cretaceous beds of Texas and neighboring regions, in showing the true order of the beds and their faunas. In this work, one of the greatest difficulties has arisen from the great variability of the Gryphæas which have served as *leitfossilien*, and from the confusion arising from mis-naming, and careless (or worse) statements regarding their occurrence and distribution. Mr. Hill, with the assistance of Mr. Vaughan, has made an exhaustive study of the whole group of Gryphæas, and determined and illustrated with numerous figures the characters of the species, their developmental history and their stratigraphic range and geographical distribution. The names of the Gryphæas (to which the name *G. pitcheri* has been applied) which survive the searching investigation are *G. corrugata* Say, *G. navia* Hall, *G. mucronata* Gabb, *G. washitaensis* Hill and *G. Newberryi* Stanton. Two new species, *G. Wardi* and *G. Marcoui*, are described. Particular attention should be called to the ontogenic study of the several species according to the Hyatt school of paleontologists.

H. S. W.

3. *Bibliographic Index of North American Carboniferous Invertebrates;* by Stuart Weller. Bull. No. 153, U. S. Geol. Survey, pp. 1–653, 1898.—The indexing and classifying of the innumerable facts regarding fossil species is a necessary prep-

aration for the new paleontology, which deals with the history of organisms rather than their form and description alone. Mr. Weller has not only opened the way for his own investigation in this direction, but has rendered a great service to all advanced students who are engaged in paleontological investigation. The matter is well arranged and the necessary statistics are given with precision and will enable the student to turn at once to the original sources of information. H. S. W.

4. *Contributions to the Tertiary Fauna of Florida, etc.;* by WM. H. DALL. Vol. iii, Part iv.—I, Prionodesmacea: Nucula to Julia, II, Teleodesmacea: Teredo to Erville; (Trans. Wagner's Free Inst. of Sci. of Philadelphia), pp. 571–947, plates xxiii–xxxv, April, 1898.—This volume maintains the characteristics of its predecessors;—the beautiful, sharply-defined illustrations and the clear and exhaustive descriptive parts, which are carried out in many cases to a thorough revision of classification of the larger divisions and the distribution of the known species, leave little to be desired in the discussion of such a group of fossil mollusca. H. S. W.

5. *Contributions to Canadian Paleontology;* by J. F. WHITEAVES; vol. i, part v, pp. 361–436, plates xlviii–l; Geol. Survey of Canada, No. 659, 1898.—This closing part of the first volume of contributions to Canadian Paleontology is chiefly concerned with the thorough revision of the nomenclature and faunas particularly noted in the previous portions of the volume, the first of which was issued in 1885.

In the first papers, the Hamilton fauna of Thedford, Widder and neighborhood in Ontario is thus revised; the additions are based upon new collections made by Mr. Schuchert, for the National Museum, in 1895 and Canadian collections examined by the author; and the revision of nomenclature is of particular importance as expressing the comparative study, of both Mr. Whiteaves and Mr. Schuchert, on large and widely distributed collections. The final list recognizes 226 species in the fauna. The second number of the part is an appendix on revision of nomenclature and statements in previous numbers of the volume. The volume being now complete, a special title page is issued with directions for binding the whole. H. S. W.

6. *Geological Survey of Canada*, G. M. DAWSON, Director, Ann. Rept. (new series), vol. ix, for 1896, pp. 816, five maps, twenty plates, Ottawa, 1898.—In addition to the summary report (614) of the operation of the survey for the current year 1896, the volume contains Tyrrell's report on the Doobaunt, Kazan and Ferguson rivers, etc. (part F), Bell's report on the French river sheet (I), Low's report on the northern part of Labrador peninsula (L), Bailey's report on S. W. Nova Scotia (M), Hoffmann's report on Chemistry and Mineralogy (S) and Ingall's report on Mineral Statistics. All of them except the Tyrrell report have been previously noted (see this Journal, iii, p. 421; iv, 78, 232, 434 and 510). H. S. W.

7. *Report on the Doobaunt, Kazan and Ferguson Rivers and the Northwest Coast of Hudson Bay, etc.;* by J. B. TYRRELL. Geol. Surv. of Canada, Ann. Rept. 1896, vol. iv, part F, pp. 1–218, plates i–xi and three maps, 1897.—This report gives account of explorations carried on during the years 1893 and 1894, in a region lying north of the 59th parallel of latitude and west of Hudson Bay, covering about 200,000 square miles. It contains much valuable geological information; a study of the movement of glaciers over the region; appendices on Chippewyan and inland Eskimos vocabularies; and a third one on plants collected by J. W. Tyrrell. H. S. W.

8. *Rivers of North America, a reading lesson for students of geography and geology;* by ISRAEL C. RUSSELL; pp. 1–327, figures 1–23, plates i–xvii. New York, 1898 (G. P. Putnam's Sons).—Prof. Russell's "Rivers of North America" is a fit companion for "Lakes of North America," "Glaciers of North America" and "Volcanoes of North America" by the same author. It is a delightful "reading lesson" for any one interested in geography or geology and will make brooks and rivers more attractive to the lover of nature. The characteristics of stream action are presented clearly in plain language without detailed discussion of laws or theories, and each point is illustrated from American rivers. The chapters on "Stream Development" and "The Life History of a River" trace the stream's history from youth to old age, tell of its birth, its efforts to adjust itself to its environment and the accidents which it may suffer. The river is made to appear as a thing of life. Students who have searched through manuals, geological reports and scattered essays for facts and laws of stream action will be thankful for the discussion of these subjects here given. H. E. G.

9. *Earth Sculpture or the origin of land forms;* by JAMES GEIKIE; pp. 1–397, pl. i–ii, figs. 1–89. New York, 1898 (G. P. Putnam's Sons).—This volume is the latest number of The Science Series published by the Putnams. The book treats first of the agents of denudation and the resulting land forms in regions of horizontal, inclined, folded and displaced strata. After this the modifying effects of igneous, glacial and æolian action on surface features are discussed. "Coast Lines" and "Classifications of Land Forms" are very useful chapters. The book is addressed to the average student who may desire some general knowledge of the development of land forms, and we know of no other English work which gives a general account of the whole subject. To American readers some of the terms and descriptions of foreign localities will seem unfamiliar and the glossary in the Appendix will be needed. This is particularly true of the divisions of the Geological Time Scale.

As an introductory treatise Prof. Geikie's book is very welcome and students of nature who have mastered this will read Sir A. Geikie's "Scenery and Geology of Scotland," Lubbock's "Scenery of Switzerland," Powell's "Canyons of the Colorado" and other physiographie classics with added interest. H. E. G.

10. *Elemente der Gesteinslehre*, von H. Rosenbusch. 8vo, pp. 546. Stuttgart, 1898.—This book is based, as the preface states, on the lectures of the author at Heidelberg. While it claims to be only an elementary treatise, it is much more than that, and will be read with interest by every petrologist as giving the latest views of its author and an excellent résumé of the present state of the science from a certain, rather subjective, standpoint.

After an introductory chapter on the general principles of petrography and the composition, structure and classification of rocks, the author describes not only the igneous rocks, to which his previous volumes have been devoted, but also the sedimentary rocks and crystalline schists.

In the portion devoted to the igneous rocks, the essexites, shonkinites and missourites have been raised to the rank of groups of the same order as the granites. The monzonites, for which Brögger has proposed a similar position, are left as a subdivision of the syenites, while among the effusive rocks a group of trachydolerites has been formed. These, according to Rosenbusch, are homologous with the essexites, but, though they resemble these in being intermediate, the examples and analyses which are given resemble more closely Brögger's monzonites. The necessity for the recognition of such groups of intermediate rocks is urgent, but this group, as here given, is the least satisfactory of all, embracing as it does many types which differ much among themselves, and it seems probable that it will undergo many changes and subdivisions in the future. It may be suggested that the name *latite* previously proposed by Ransome seems preferable to the coextensive term of trachydolerite used by Rosenbusch.

The sedimentaries are very fully and satisfactorily treated and the same is true of the metamorphic schists. For schists derived from igneous rocks the author proposes the use of the prefix *ortho*, and for those derived from sedimentaries the prefix *para*, so that we would have orthogneiss, paragneiss, etc.

In general the views held by the author are the same as those expressed in his previous works. The age distinction is practically banished, but traces of it still survive among the effusives.

The chemical characters of the various rocks are discussed in considerable detail, and a valuable feature is the insertion of tables of typical analyses, not only of the rocks themselves but of their component minerals, many of which are published here for the first time. They are in general well selected, but the almost total lack of references throughout the book, especially for the analyses, is to be deplored, even though such omissions are due to the elementary character of the work.

But such criticisms are chiefly matters of personal opinion, and the name of the author is sufficient guarantee for the high character of the volume. It should prove a valuable text-book for the German-reading student, and will be a much used addition to the library of every petrologist. H. S. W.

11. *The Educational Series of Rock Specimens collected and distributed by the U. S. Geological Survey;* by J. S. DILLER. Bulletin No. 150, U. S. Geol. Surv., Washington, 1898, pp. 400, 47 pl.; price 25 cts.—A number of years ago the United States Geological Survey undertook the praiseworthy task of collecting and distributing to our leading educational institutions, as an aid in geological teaching, a series of rock collections illustrating the petrology of the United States. Under the able management of Mr. J. S. Diller, aided by many geologists both of the Survey staff and from other portions of the country, this task was sucessfully completed, and about 250 sets, comprising over 150 specimens in each, were distributed. In addition, to supplement the value of these collections, the Survey has now issued the volume above mentioned, in which the rocks are described from the standpoint of modern petrography. Under the editorship of Mr. Diller, who also contributes largely to the descriptive matter, the rocks have been described by a number of specialists, in great part those by whom they were collected, and to whom is due our knowledge of the geology of the regions in which they occur.

The method of classification is simple and rational, and the volume constitutes in fact an excellent practical text-book of petrology for Americans, and as such will be found of very great service to teachers of geology, as well as to those engaged in the more specialized petrographical branches. Its appearance in connection with the use of the collections cannot fail to give an impulse to the study of petrography, and the Survey staff in general, and Mr. Diller in particular, deserve great credit for the completion of this useful and public-spirited work. L. V. P.

12. *The Mechanical Composition of Wind Deposits;* by JOHAN AUGUST UDDEN, pp. 1–69. Augustana Library Publications, No. 1. Rock Island, Ill., 1898.—The author has carried on a long series of observations in order to show the part played by the air in motion in transporting sand deposits to different distances as determined by their size. Four classes are especially recognized: (1) lag gravels or coarse residue deposits in the rear of sand dunes; (2) drifting sand, constituting the sand dunes of dry and sandy regions; (3) fine sand, soon dropped by the wind in the lee of drifting dunes; (4) atmospheric dust, which only slowly settles out of the air far away from the place where it was raised.

Many observations in regard to each of these have been made at different points, chiefly in Illinois, Indiana, Nebraska, Kansas and the Dakotas. The results, given in the form of numerous tables, show the percentage of particles of characteristic size present under the given conditions. For example, lag gravels, though varying widely in different localities, include chiefly particles from 4^{mm} to $\frac{1}{4}^{mm}$ in diameter; drift sands those from 1^{mm} to $\frac{1}{8}^{mm}$; dune sand is more uniform, from 60 to 70 or 80 per cent of the particles ranging between $\frac{1}{4}$ and $\frac{1}{8}^{mm}$; lee sand runs down to $\frac{1}{16}^{mm}$ or smaller, and atmospheric dust varies from $\frac{1}{8}$ to $\frac{1}{128}^{mm}$ and

smaller. The approximate maximum distances over which quartz fragments may be lifted by moderately strong winds in single leaps are estimated as follows:

Gravel (8–1^{mm} diam.)	A few feet.
Coarse and medium sand (1–$\frac{1}{4}^{mm}$)	Several rods.
Fine sand ($\frac{1}{4}$–$\frac{1}{8}^{mm}$)	Less than a mile.
Very fine sand ($\frac{1}{8}$–$\frac{1}{16}^{mm}$)	A few miles.
Coarse dust ($\frac{1}{16}$–$\frac{1}{32}^{mm}$)	200 miles.
Medium dust ($\frac{1}{32}$–$\frac{1}{64}^{mm}$)	1000 miles.
Fine dust ($\frac{1}{64}^{mm}$ and less)	Around the globe.

A striking result brought out is the comparative definiteness with which the different grades are separated from each other by the sorting action of the wind. In closing, the author discusses briefly the relation of the facts brought out by his investigations to the origin of the loess deposits, which in their mechanical composition certainly resemble atmospheric sediments. He does not regard it possible, however, to reach a final conclusion from the data at hand.

13. *Brief notices of some recently described Minerals.*—SENAITE is a new mineral, related to ilmenite, described by Hussak and Prior. It is found in rounded fragments and rough crystals in the diamond-bearing sands of Diamantina, Minas Geraes, Brazil. Crystallization like ilmenite, rhombohedral-tetartohedral (trirhombohedral). Hardness about 6, specific gravity of crystals, 5·30, massive 4·78 to 4·22; luster sub-metallic and color black, in thin splinters, greenish. Analysis gave:

	TiO_2	PbO	FeO	Fe_2O_3	MnO	MgO	SnO_2
G...4·78	57·21	10·51	4·14	20·22	7·00	0·49	0·11=99·68

The formula (Fe, Pb) O.2(Ti Mn) O_2 is suggested, but doubtful.—*Min. Mag.*, xii, 30, 1898.

MOSSITE is a name given by Brögger to a nisbo-tantalate of iron occurring with yttro tantalite at Moss, Norway. It is found in black tetragonal crystals with $c = 0·644$. The crystals are mostly twins with (101) as twinning plane; they are often distorted by elongation parallel to (111) as is sometimes observed with rutile. An analysis gave $(N6,Ta)_2O_5$ 82·92, FeO 16·62, SnO_2 0·18 = 99·72, which corresponds to the formula Fe $(N6, Ta)_2O_4$; further it was found that N6 : Ta = 1 : 1. The author shows that mossite is near tapiolite, which, however, is richer in Ta_2O_5 and has $c = 0·652$. He has also made the interesting observation that the crystals of "tantalite" which have long been figured in the text-books, are in fact identical with tapiolite, being twin crystals similar to those mentioned above.—*Vid. Skrift. Math.-nat. Klasse*, 1887.

VALLÉITE is a mineral closely related to anthophyllite occurring with the violet tremolite of Edwards, N. Y.; it is described by G. Cesàro. Crystallization orthorhombic; occurs in colorless prismatic crystals with the usual amphibole angles of 125° 30′ and 54° 30′. The cleavage is prismatic and pinacoidal. The hardness is 4·5, specific gravity 2·88. Analysis gave:

SiO_2	MgO	CaO	Fe_2O_3	MnO	K_2O	H_2O
58·02	27·99	5·04	1·28	2·88	0·89	3·13 = 99·23

The formula is $RSiO_3$, or that of anthophyllite, from which it is stated to differ somewhat in optical characters ($\gamma - \alpha = 0{\cdot}0036$).—*Zeitschr. Kryst.*, xxx, 84.

CEDARITE is a fossil resin, resembling amber, from the alluvium of the Saskatchewan river, Canada. Analysis gave: C 78·15, H 9·89, S 0·31, O 11·20, ash 0·45 = 100. Described by R. Klebs, *Jahrb. Min.*, ii, 212 ref., 1898.

BATAVITE, described by Weinschenk, is a decomposition product occurring with the graphite deposits near Passau, Bavaria. It occurs in white pearly scales with a specific gravity of 2·183. Analysis gave: SiO_2 42·33, Al_2O_3 16·35, MgO 28·17, H_2O 13·19 = 100 04. For this the composition suggested is $H_8Mg_4Al_2Si_4O_{19}$.—*Zeitschr. Kryst.*, xxviii, 160.

GRÜNLINGITE, described by Muthmann and Schröder, is a sulpho-telluride of bismuth, related to tetradymite, from Cumberland, England. It was earlier investigated by Rammelsberg, but the authors have obtained on analysis a composition agreeing with the formula Bi_4S_3Te or Bi(S, Te). It appears in cleavable masses with metallic luster and gray color; the specific gravity is 7·321. Named after Dr. F. Grünling of Munich.—*Ibid.*, xxix, 144.

PLANOFERRITE, described by L. Darapsky, is a hydrated ferric sulphate from the Lautaro copper mine in Atacama. It occurs in tabular crystals which are colorless or lemon-yellow. An analysis gave: SO_3 15·57, Fe_2O_3 31·20, H_2O 51·82, insol. 1·41 = 100. This corresponds to $Fe_2O_3 . SO_3 . 15\,H_2O$.—*Ibid.*, xxix, 213.

III. BOTANY AND ZOOLOGY.

1. *The Poisonous effect exerted on living plants by Phenols.* (Botan. Centralblatt, Nov. 15, 1898.)—Professor R. H. TRUE has extended his fruitful investigations respecting the action of toxic substances far beyond the boundaries which he originally marked out. With efficient collaborators, he studied two years ago the effects of salts, acids, and bases, on one of the Leguminosæ, and had the satisfaction of having the results substantially confirmed by other experimenters, and the suggestions carried into a wider field. With Mr. Hunkel, he returns to the task, and obtains results which appear to confirm the belief that the whole subject of Toxicology is to receive abundant light from the study of plants. It is well known that the meagre information regarding the action of active remedial agents on plants, embodied in the Dispensatories, is unsatisfactory, but it certainly indicates a desire on the part of the commentators to get what little light glimmers through the obscure experimentation. Now, of late years, the whole subject has been placed on a different basis, and the work done upon this basis is creditable alike in its suggestion and its execution. It is not yet time to summarize the details or

attempt their complete co-ordination, but it is not too soon to predict that materials will before long be sufficient for a rational discussion of many obscure points in Toxicology and, we dare to hope, in Therapeutics. To the energy and carefulness with which Dr. True has prosecuted his work thus far, we owe most important contributions, and we trust he will be encouraged to carry his researches still further afield. The new paths which he has been instrumental in opening up are likely to attract many explorers. It is to be sincerely wished that all who enter the new field will bring to the work the same acuteness, patience, and thoroughness which seem to characterize the work thus far. To those of our readers who may like to know the thought which inspires the work, we may use words of Dr. True, which are abundantly justified. "The application of the theory of dissociation of electrolytes to explain the toxic action of acids, bases, and salts, on living organisms has yielded results of greatest import to both chemistry and biology." Now beyond these substances others are to be investigated by the same methods: let us hope with equally satisfactory results. G. L. G.

2. *On the peculiar mode of formation of pollen-grains in Magnolias.*—In the number of Comptes Rendus for Oct. 24, 1898, GUIGNARD gives an extremely interesting account of one of the puzzling exceptions to general rules, which are full of suggestions as to classification of organisms.

The author calls attention to the general characters of pollen formation which serve to separate more or less completely monocotyledons from dicotyledons. In the former, the first division of the nucleus of the mother-cell is followed by partition of the latter, and then the two daughter-cells divide in their turn, in the same way. In dicotyledons, on the other hand, the first nuclear division is not followed by partition of the mother-cell; that does not take place until after the second nuclear division, between the four nuclei which it has furnished.

Now to this general rule, Guignard had already pointed out a remarkable exception, namely, that among the monocotyledons are to be found plants which behave in this respect just as do the dicotyledons. These exceptions are the *Orchidaceæ*. They nearly all undergo simultaneous quadripartition of the pollinic mother cell. The author now announces that in the *Magnolias* is to be seen a type of division unlike either the first or the second. The type is almost intermediate between the two hitherto recognized, but by the formation of an incomplete partition (possibly sometimes complete) immediately after the first nuclear bipartition, is more like that of the monocotyledons than of the dicotyledons. G. L. G.

3. *Elements de Botanique.* P. VAN TIEGHEM. 2 volumes, 16mo. Paris, 1898.—In this revised edition of a helpful work, Professor Van Tieghem gives his own views regarding certain disputed points relative to structure, and states his reasons for suggesting a new classification of the higher plants. The princi-

pal features of this new system have already been presented in this Journal, and therefore need not be again spoken of in detail. But it seems proper to mention the fact that Professor Van Tieghem's system, although distinctly revolutionary, appears to offer advantages in practical ways, especially in bringing out clearly the disguised resemblances. The author has done good service in emphasizing a good many things which have been more or less overlooked in previous systems. It is not improbable that some of these things have been insisted on rather too strongly, and in this way, may throw the system somewhat out of proportion, but thus far, this does not seem to be the case. At any rate, the sense of general proportion is good, and, as a natural result, the perspective is not misleading. Teachers will find a good many fruitful suggestions in every part of the two volumes, but most of all in the portion devoted to classification. G. L. G.

4. *Sketch of the Evolution of our Native Fruits;* by L. H. BAILEY; pp. xiii+472, 125 figures in text. New York, 1898 (The Macmillan Co.).—During the past ten years Professor Bailey has made a study of our indigenous fruits and of the cultivated varieties to which they have given rise. Some of the results of his investigations have already appeared in periodicals, and the present volume brings these scattered observations together and presents the whole subject in a more complete and connected form. The greater part of the book deals with the more important of our fruits, those which are most widely cultivated and which are consequently represented by the greatest number of cultivated varieties. These include the grape, the mulberry, our native plums, cherries and apples, the raspberry, the blackberry and the dewberry. The chapter on the grape, though particularly exhaustive, may indicate the scope of the work: in addition to a history and description of our various native grapes and of their cultivated varieties, it gives an account of the early attempts and failures to introduce the European grape into eastern America and concludes with a full bibliography of American grape literature. At the close of the book some attention is paid to our less important fruits, the gooseberries, currants, etc., which, although less widely cultivated, offer considerable promise to the cultivator. A. W. E.

5. *Bush-Fruits: a Horticultural Monograph of Raspberries, Blackberries, Dewberries, Currants, Gooseberries, and other Shrub-like Fruits;* by FRED. W. CARD; pp. xii+337, 113 figures. New York, 1898 (The Macmillan Co.).—The present book is the first of a proposed series of monographs dealing with the various types of American fruits. As its title indicates, it is distinctly horticultural and devotes its chief attention to a description of the varieties of the "bush-fruits" enumerated and of the methods employed in their cultivation. A. W. E.

6. *The Metamorphosis of Asterias pallida* [*A. vulgaris*] *with special reference to the fate of the Body Cavities;* by S. GOTO. Jour. College Science Imp. Univ. Tokyo, Japan, vol. x, pt. iii,

pp. 239–278, pl. xix–xxiv, 1898.—This important paper relates to the common northern starfish of New England. It is the result of work done at the Newport laboratory of Mr. A. Agassiz and at the Museum of Comp. Zoology of Harvard University. v.

7. *Zoological Results based on material from New Britain, New Guinea, Loyalty Islands, and elsewhere, collected during* 1895–1897; by ARTHUR WILLEY. Part I. Cambridge, Eng., Univ. Press.—The first article consists of a very detailed account of the development and anatomy of *Peripatus Novæ-Britanniæ*, sp. nov., illustrated by four plates. The second is devoted to a new species of Caprellidæ (*Metaprotella Sandalensis*). The third is on a sea-snake from the South Pacific, *Aipysurus annulatus* (Krafft), with figure. The fourth is a Report on the Centipedes and Millipedes, pl. vi. The fifth is on the Phasmidæ with notes on the eggs, pl. vii–ix. The sixth paper relates to the Pedapalp and Scorpions, pl. x, xi. v.

8. *An Account of the Crustacea of Norway, with figures of all the species;* by G. O. SARS Vol. II, parts xi, xii. Oniscidæ, Bopyridæ, Dajidæ; 4to. Bergen. Published by the Bergen Museum, 1898.—This is a continuation of the admirable work of Professor Sars on the Norwegian Crustacea. This part contains eight autographic plates drawn by Dr. Sars himself, with his customary care and accuracy. This work is of special interest to American naturalists, because a considerable percentage of the species will be found also on our coast. v.

9. *The Mollusca of the Chicago Area: The Pelecypoda;* by FRANK COLLINS BAKER, pp. 1–130, with 27 plates. The Chicago Academy of Sciences, Bulletin No. iii, Part i of the Natural History Survey, Sept. 1, 1898.—This exhaustive and liberally illustrated memoir by Mr. Baker has recently appeared. A second part, devoted to the Gastropoda, is promised.

10. *Catalogus Mammalium tam viventium quam fossilium a* Doctore E.-L. TROUESSART, Parisiis. Nova Editio (Prima completa). Fasciculus IV, pp. 665–998; V, pp. 999–1264. Berlin, 1898 (R. Friedländer & Son).—Parts i–iii of the exhaustive Bibliography of papers relating to living and fossil mammals, by Dr. Trouessart, have already been announced in our pages. Parts iv and v have now appeared, embracing some six hundred pages and bringing this important work to a close. Part iv includes the Tillodontia and Ungulata: Part v the Sirenia, Cetacea, Edentata, Marsupialia, Allotheria, and Monotremata. The genera included in these two parts extend from Nos. 761 to 1588, and the species from Nos. 4086 to 7224; and besides there are many varieties not separately numbered. The whole bibliography is printed with admirable clearness.

11. *The Fishes of North and Middle America;* by DAVID STARR JORDAN and BARTON WARREN EVERMANN; pp. i–xxx, 1241–2183. Washington, 1898 (Bulletin 47 of the U. S. National Museum, Smithsonian Institution).—Part II of the complete descriptive catalogue of the fishes found in the waters of North

America north of the Isthmus of Panama, by Jordan and Evermann, has recently been issued. Part I was published in October, 1896. The third and final part with index, glossary, etc., is promised soon; it will be followed by a fourth volume which will be an atlas of plates.

IV. Miscellaneous Scientific Intelligence.

1. *Institute of France.*—At the session of the *Académie des Sciences* held at Paris, December 5, 1898, Professor O. C. Marsh of Yale University, to whom the Cuvier prize was awarded a year since, was elected Correspondent of the Academy.

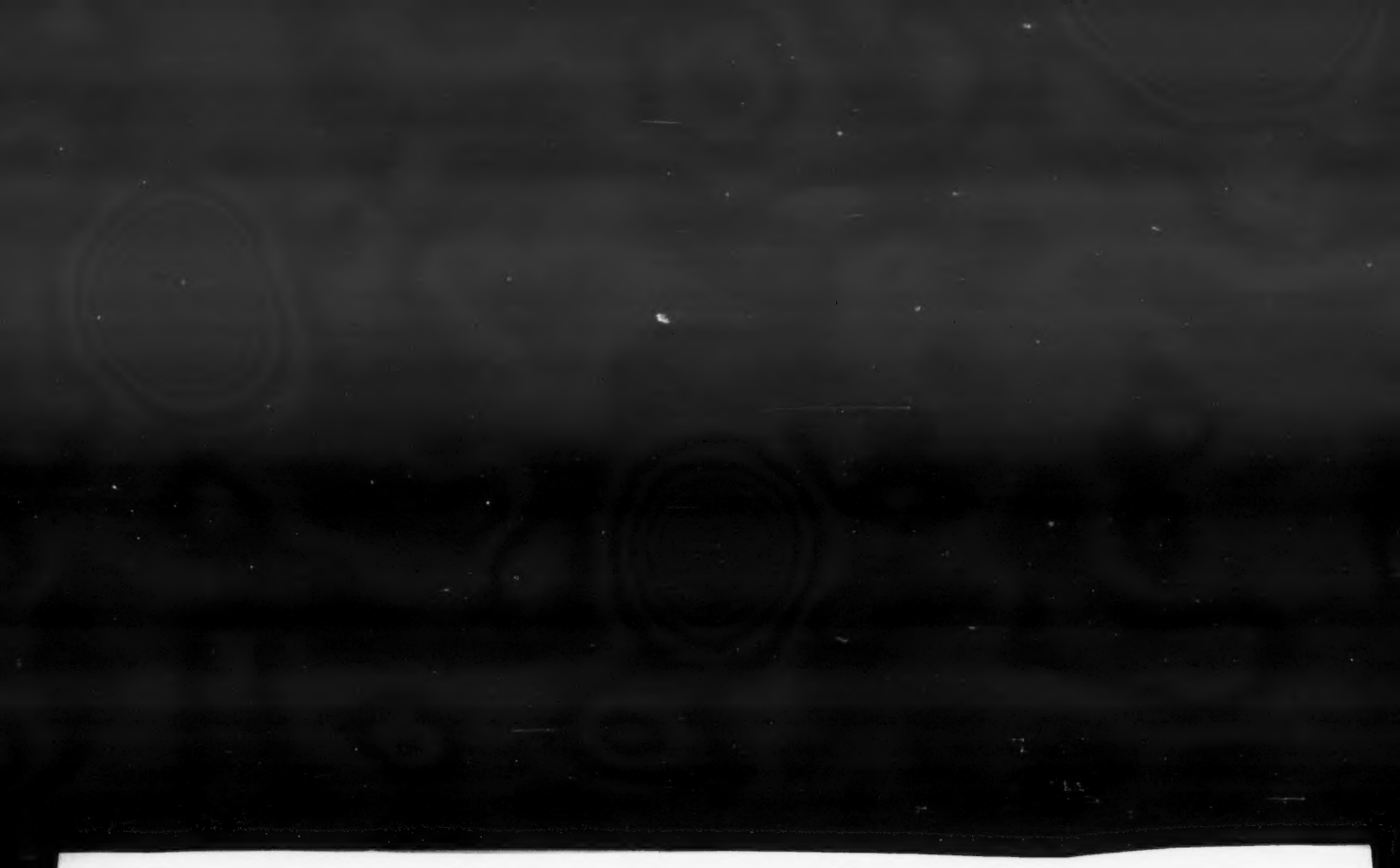
2. *Annual Report of the Board of Regents of the Smithsonian Institution* showing the operations, expenditures and condition of the Institution to July, 1896; pp. i–li, 1–727; plates i to lxi.—This valuable report submitted to Congress by the Secretary, S. P. Langley, has recently appeared. The opening portion (pp. 1–77) are given to matters of administrative detail in regard to the work of the Institution in its different departments. The General Appendix (pp. 89–727) contains as usual a series of scientific papers on a wide range of topics, the republication of which in this place is a boon to many interested in science.

3. *Der Ursprung der Afrikanischen Kultur* von L. Frobenius, pp. i–xxxi, 1–368, with 5 folded charts, 9 plates and 225 illustrations in the text. Berlin, 1898 (Gebrüder Borntraeger).—This is the opening volume of what promises to be an extensive and important work, devoted to the origin of culture in general. The subject of the volume is the origin of culture in Africa, and this is treated with much fullness and abundance of illustration. Some of the topics discussed in detail are the weapons, shields, knives, etc.; also the various kinds of musical instruments, the different forms of huts and household utensils. The latter portion of the work deals with the physiological side of the subject in its varied aspects.

4. *Organic Evolution Considered;* by Alfred Fairhurst, pp. 1–386. Christian Publishing Co., St. Louis, 1897.—In regard to his work the author states: "I look upon the theory of evolution as being of no importance except as it involves the well-being of man. . . My object in what I have written is to promote the belief in theism and in the existence of a spiritual nature in man which theism alone can explain."

Catalogues recently issued.

Catalogue of Books and Papers on Chemistry and Physics, No. iv. Dulau and Co., 37 Soho Square, London, W., 1898.

Dr. F. Krantz, Rheinisches Mineralien-Contor in Bonn.—Katalog Nr. 1a (Siebente Auflage), Mineralien and Mineralpräparate, Mineralogische Apparate und Utensilien, pp. i–xii, 1–113, 1898.

Catalogue and Price List of Minerals for Scientific and Educational Purposes. Loose crystals a specialty. Roy Hopping, 5 and 7 Dey Street, New York City. 1899.